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(54) **METHOD AND APPARATUS FOR ENCODING VIDEO USING ADJUSTABLE LOOP FILTERING, AND METHOD AND APPARATUS FOR DECODING VIDEO USING ADJUSTABLE LOOP FILTERING**

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USPC **375/240.24**

(57) **ABSTRACT**

Provided is a method of decoding a video by using a video decoding processor, the method including: extracting encoding information and encoded video data by receiving and parsing a bit stream of a video; decoding the encoded video data for each coding unit which is a data unit for decoding the video data, by using the encoding information; performing loop filtering on the coding unit with respect to the decoded video data by using internal pixels of the coding unit based on a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit; and restoring the video by combining the decoded video data and data on which the loop filtering is performed, for each coding unit.

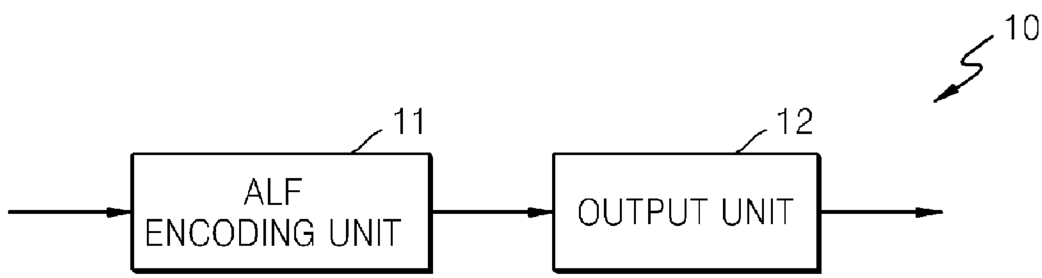


FIG. 1

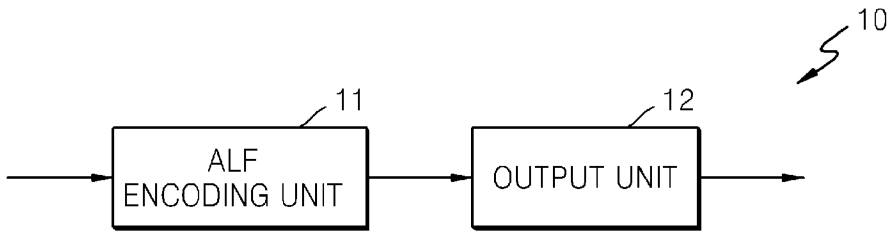

10
11
ALF
ENCODING UNIT
12
OUTPUT UNIT

FIG. 2

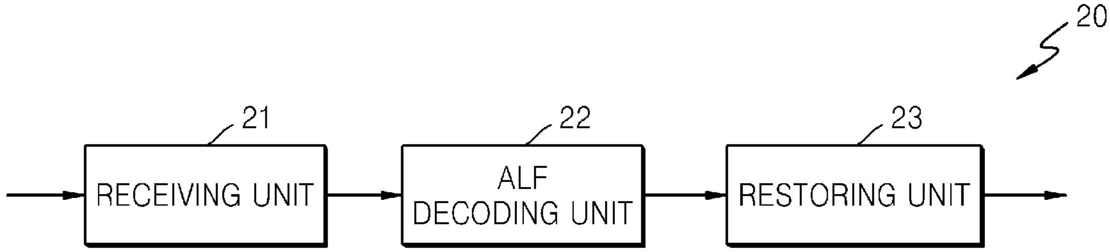

20
21
RECEIVING UNIT
22
ALF
DECODING UNIT
23
RESTORING UNIT

FIG. 3

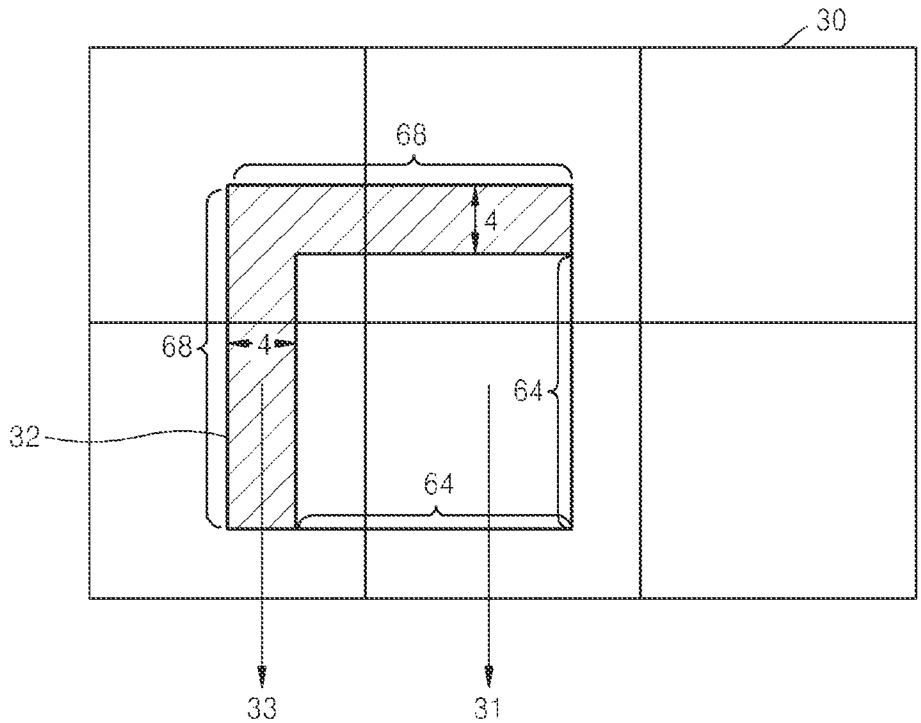


FIG. 4

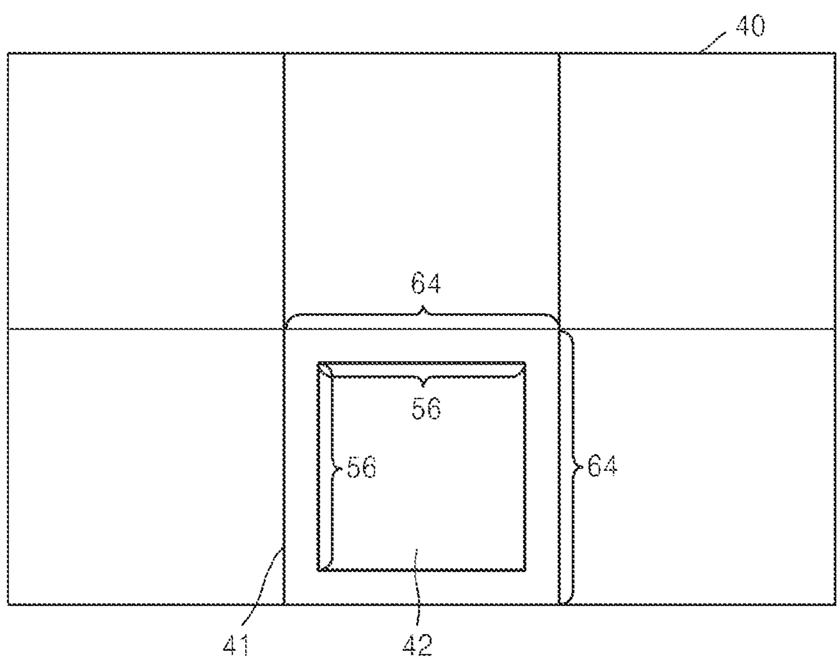


FIG. 5

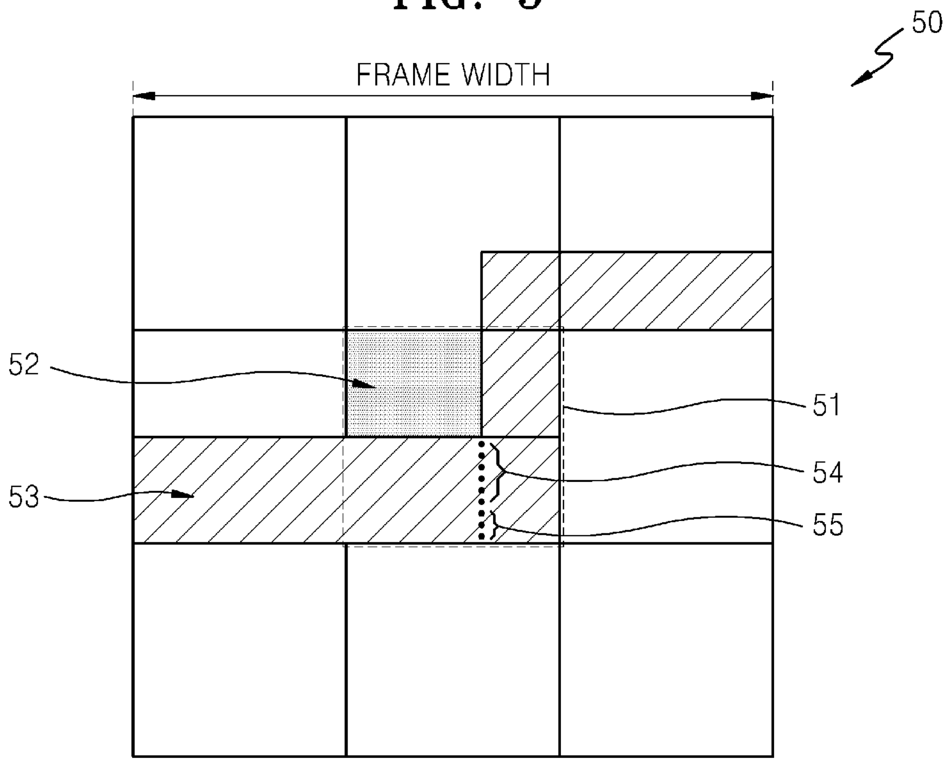


FIG. 6

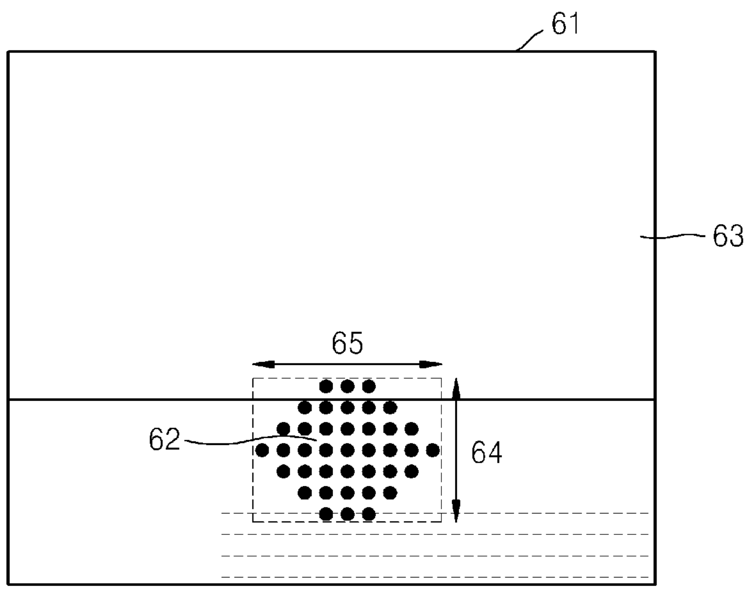


FIG. 7

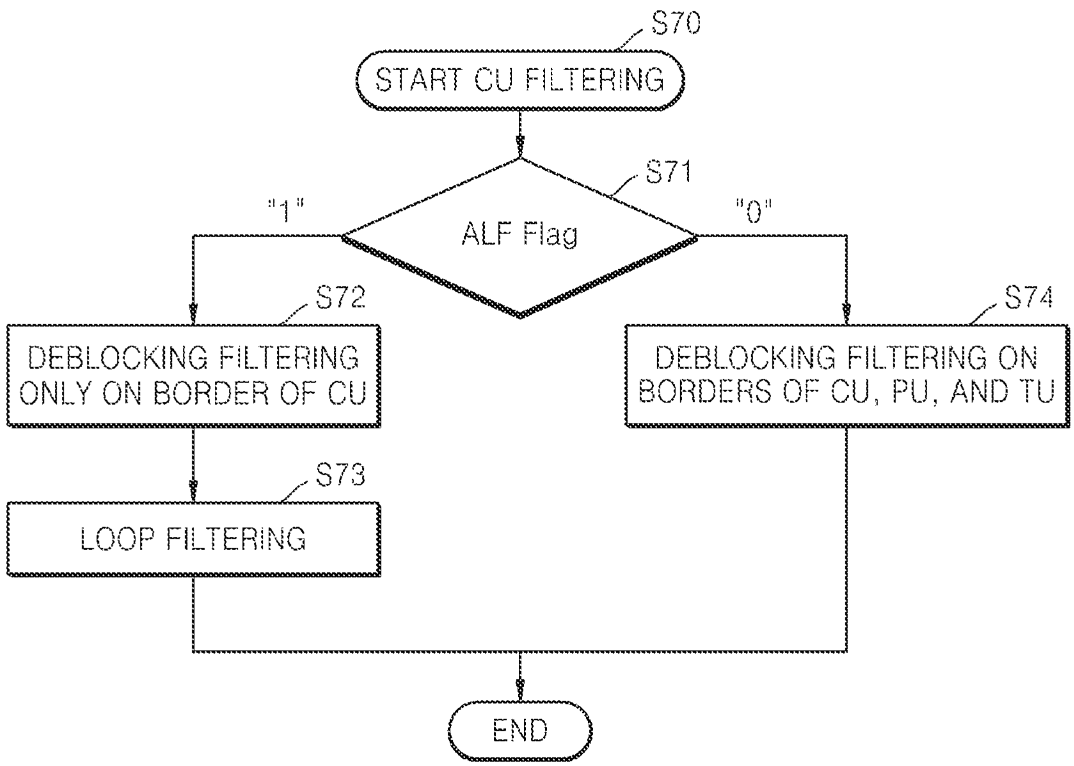

S70
START CU FILTERING
S71
ALF Flag
"1"
"0"
S72
DEBLOCKING FILTERING ONLY ON BORDER OF CU
S73
LOOP FILTERING
S74
DEBLOCKING FILTERING ON BORDERS OF CU, PU, AND TU
END

FIG. 8

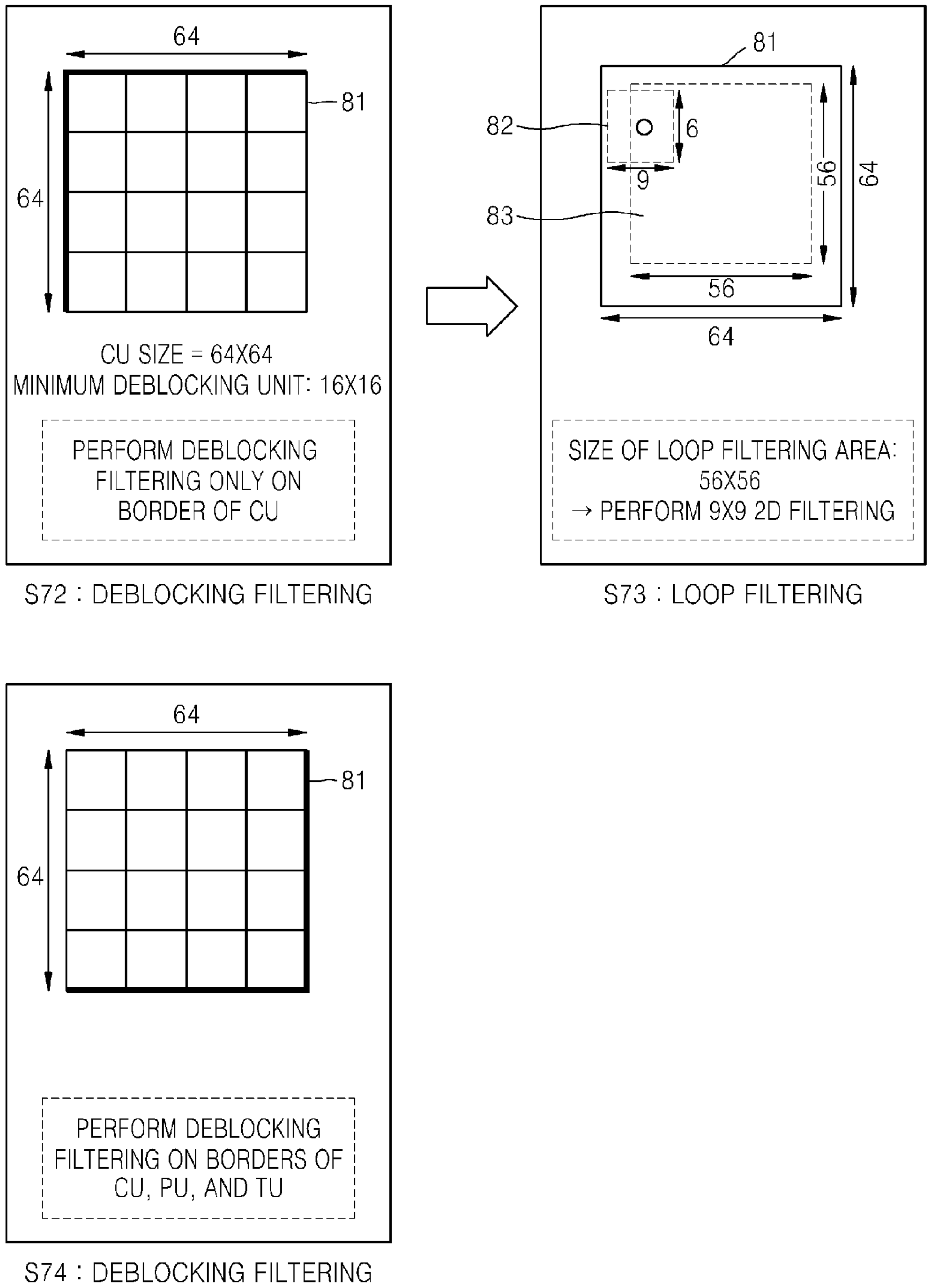

64
64
81
CU SIZE = 64X64
MINIMUM DEBLOCKING UNIT: 16X16
PERFORM DEBLOCKING FILTERING ONLY ON BORDER OF CU
S72 : DEBLOCKING FILTERING
81
82
83
6
9
56
56
64
64
SIZE OF LOOP FILTERING AREA: 56X56
→ PERFORM 9X9 2D FILTERING
S73 : LOOP FILTERING
64
64
81
PERFORM DEBLOCKING FILTERING ON BORDERS OF CU, PU, AND TU
S74 : DEBLOCKING FILTERING

FIG. 9

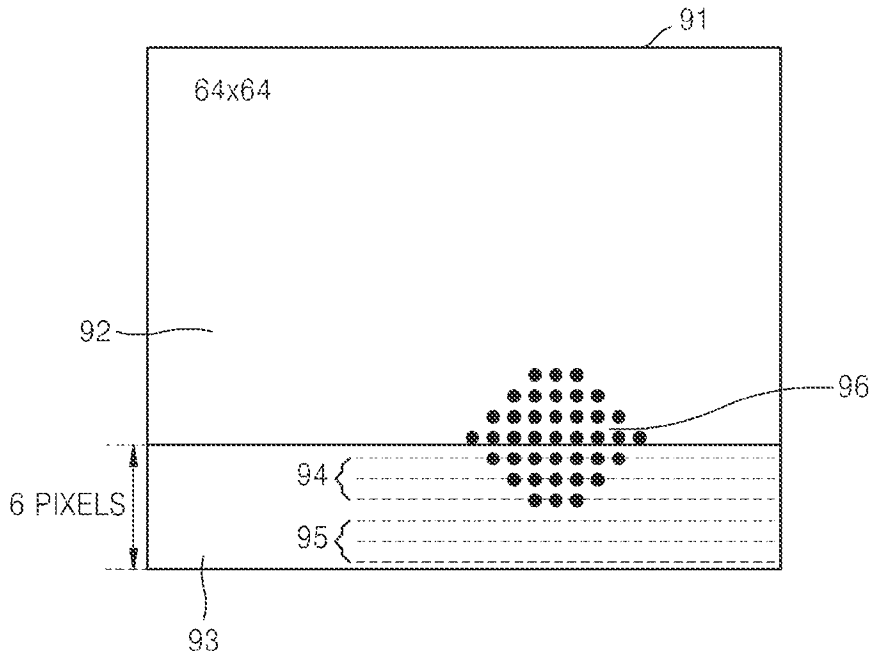

91
64x64
92
96
94
6 PIXELS
95
93

FIG. 10

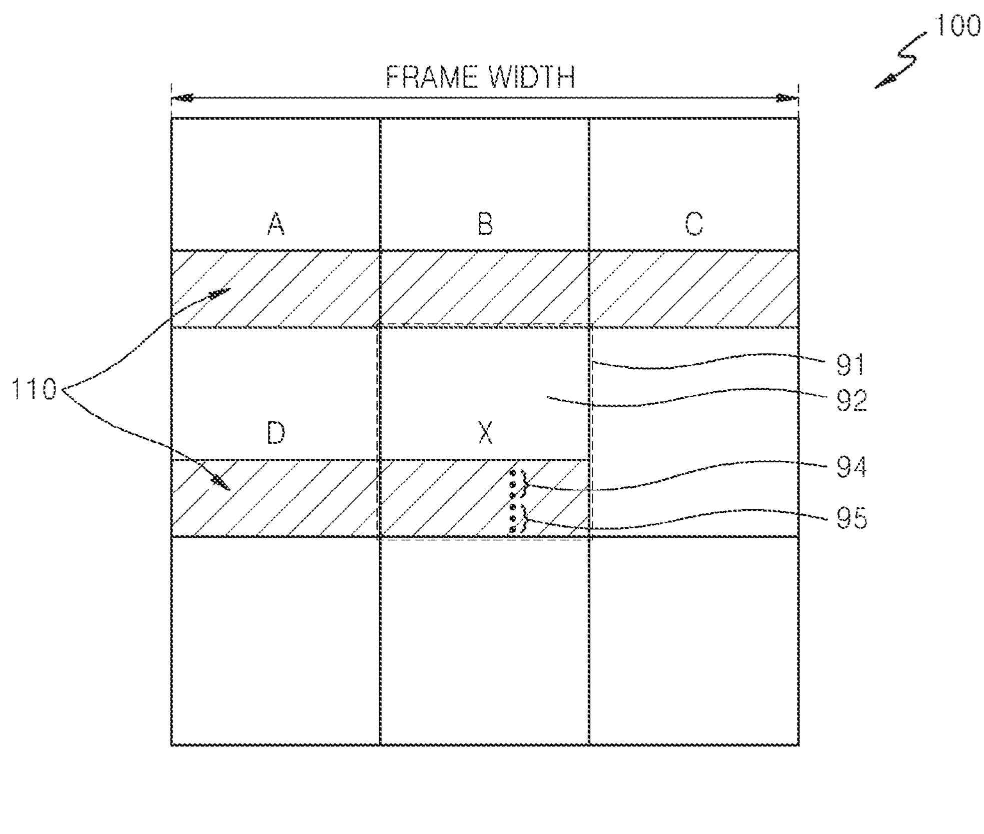

100
FRAME WIDTH
A
B
C
110
D
X
91
92
94
95

FIG. 11

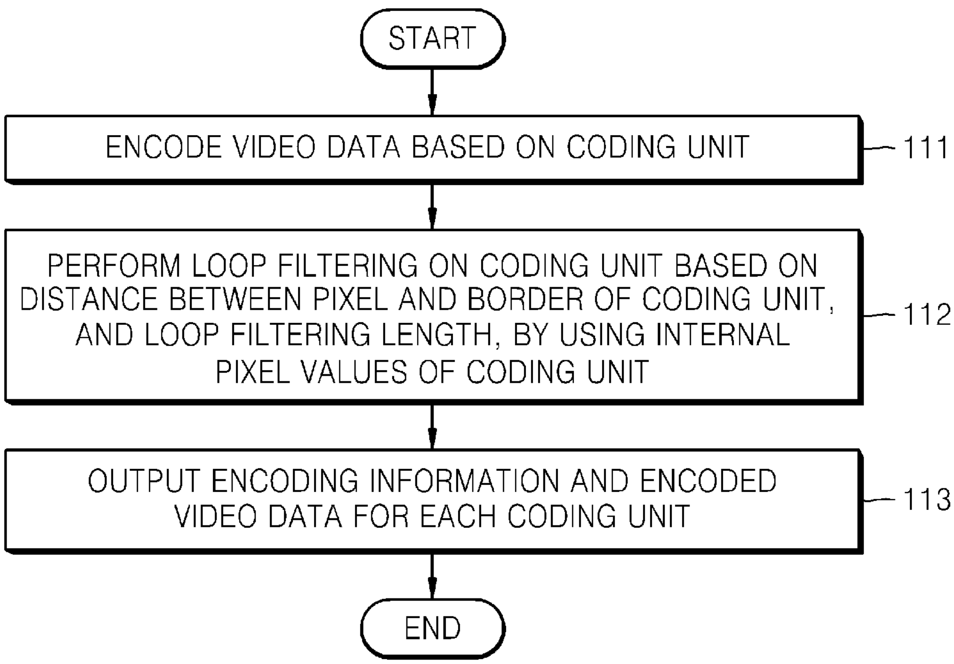

START
ENCODE VIDEO DATA BASED ON CODING UNIT
111
PERFORM LOOP FILTERING ON CODING UNIT BASED ON DISTANCE BETWEEN PIXEL AND BORDER OF CODING UNIT, AND LOOP FILTERING LENGTH, BY USING INTERNAL PIXEL VALUES OF CODING UNIT
112
OUTPUT ENCODING INFORMATION AND ENCODED VIDEO DATA FOR EACH CODING UNIT
113
END

FIG. 12

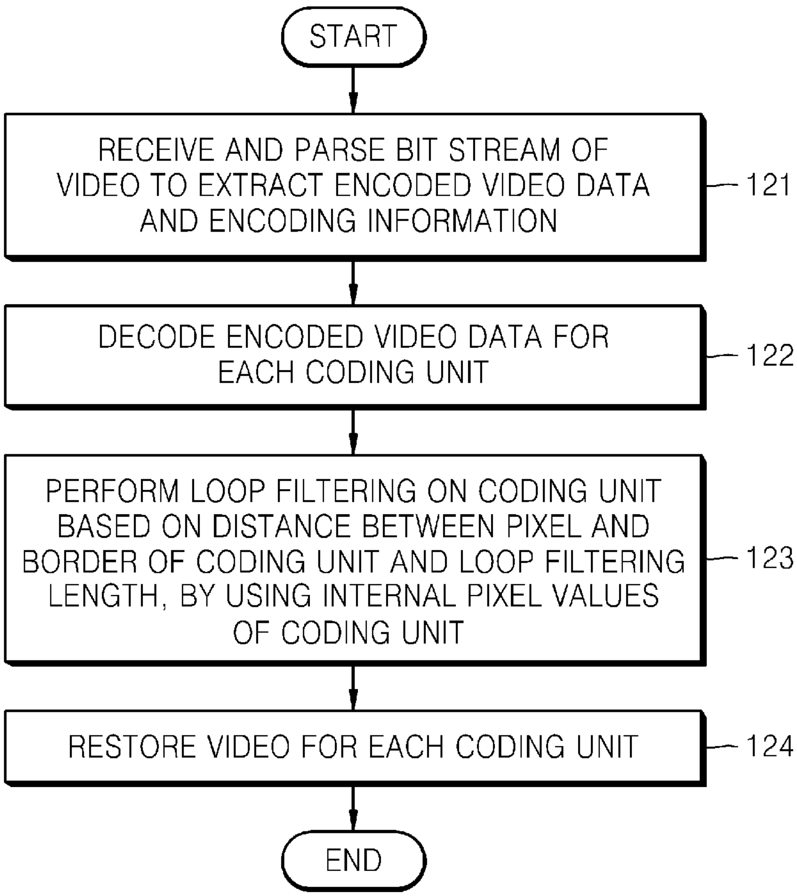
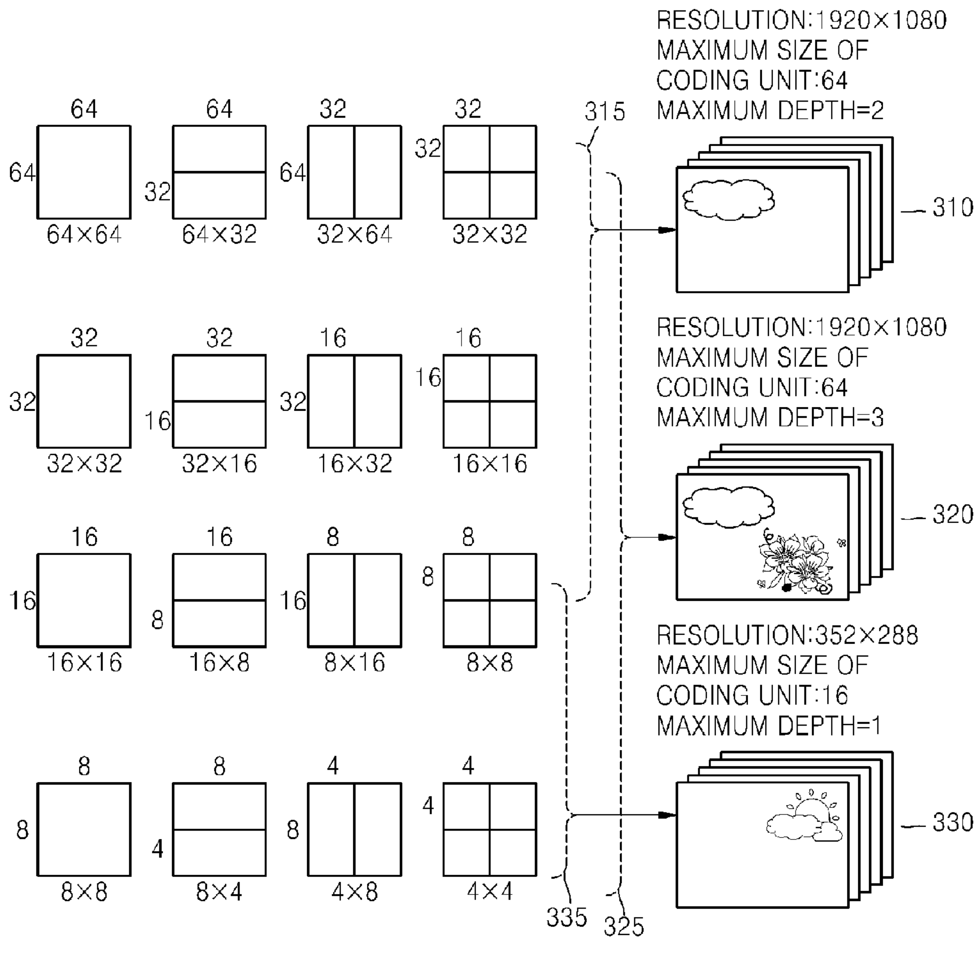

START
RECEIVE AND PARSE BIT STREAM OF VIDEO TO EXTRACT ENCODED VIDEO DATA AND ENCODING INFORMATION
121
DECODE ENCODED VIDEO DATA FOR EACH CODING UNIT
122
PERFORM LOOP FILTERING ON CODING UNIT BASED ON DISTANCE BETWEEN PIXEL AND BORDER OF CODING UNIT AND LOOP FILTERING LENGTH, BY USING INTERNAL PIXEL VALUES OF CODING UNIT
123
RESTORE VIDEO FOR EACH CODING UNIT
124
END

FIG. 13



RESOLUTION:1920×1080
MAXIMUM SIZE OF
CODING UNIT:64
MAXIMUM DEPTH=2
RESOLUTION:1920×1080
MAXIMUM SIZE OF
CODING UNIT:64
MAXIMUM DEPTH=3
RESOLUTION:352×288
MAXIMUM SIZE OF
CODING UNIT:16
MAXIMUM DEPTH=1
64×64
64×32
32×64
32×32
32×16
16×32
16×16
16×8
8×16
8×8
8×4
4×8
4×4
315
325
335
310
320
330

FIG. 14

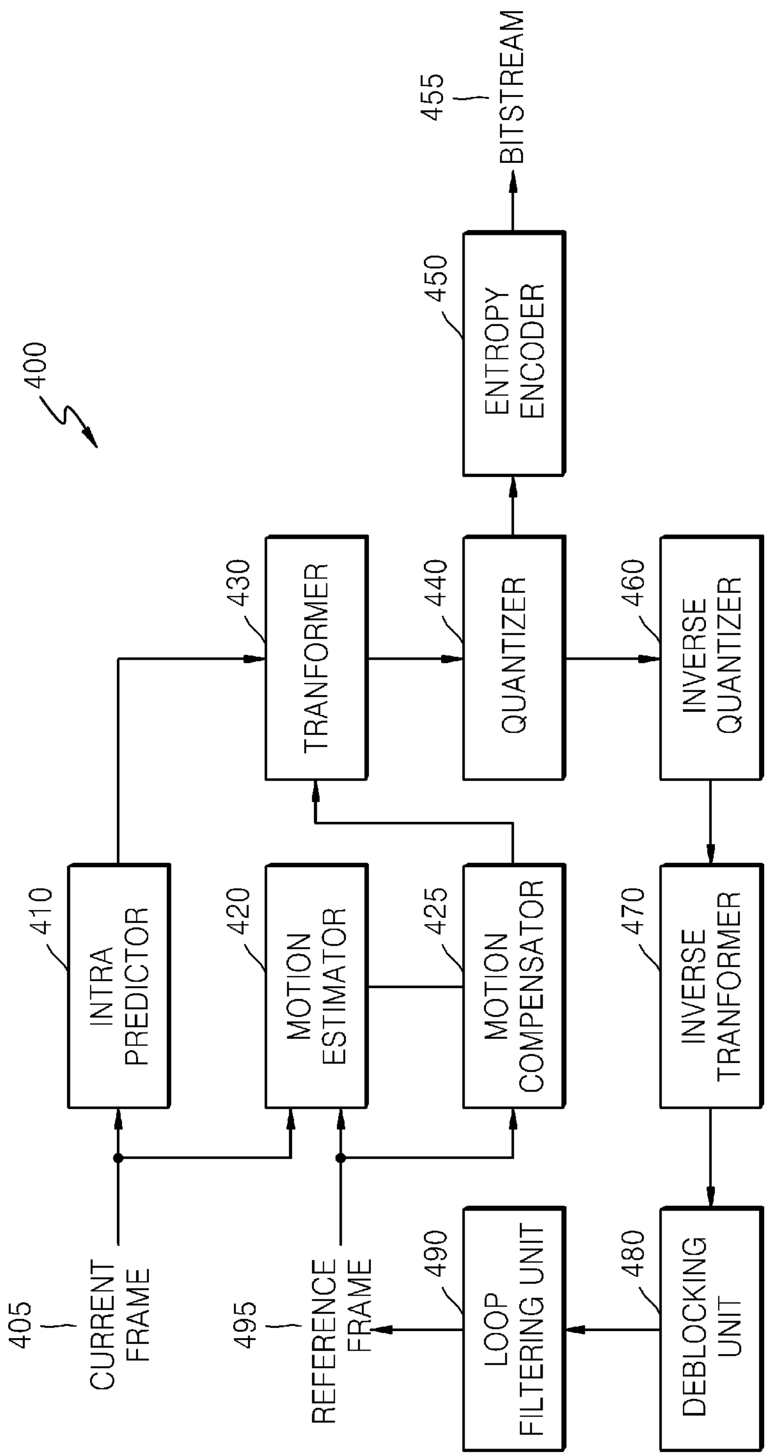

400
405
CURRENT FRAME
410
INTRA PREDICTOR
420
MOTION ESTIMATOR
425
MOTION COMPENSATOR
430
TRANFORMER
440
QUANTIZER
450
ENTROPY ENCODER
455
BITSTREAM
460
INVERSE QUANTIZER
470
INVERSE TRANFORMER
480
DEBLOCKING UNIT
490
LOOP FILTERING UNIT
495
REFERENCE FRAME

FIG. 15

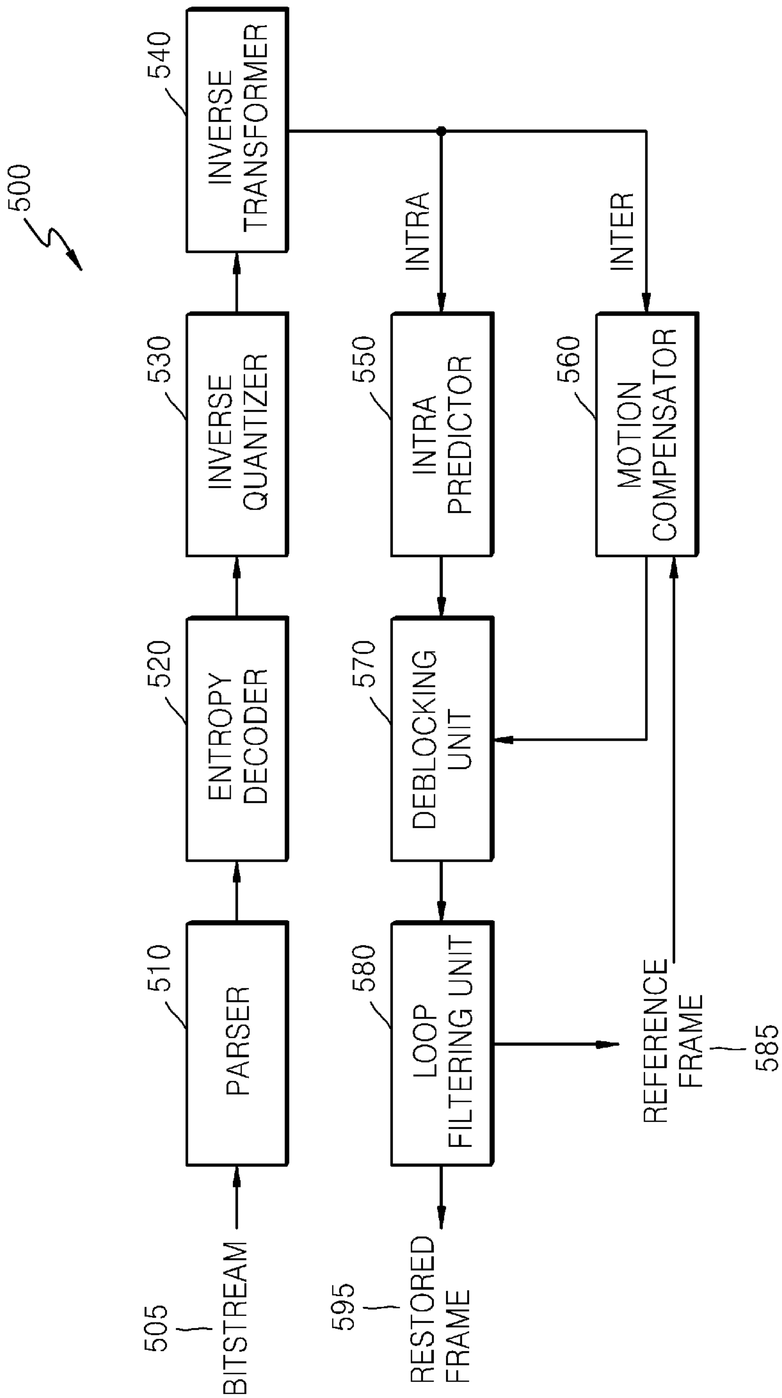

500
505
BITSTREAM
510
PARSER
520
ENTROPY DECODER
530
INVERSE QUANTIZER
540
INVERSE TRANSFORMER
INTRA
INTER
550
INTRA PREDICTOR
560
MOTION COMPENSATOR
570
DEBLOCKING UNIT
580
LOOP FILTERING UNIT
585
REFERENCE FRAME
595
RESTORED FRAME

FIG. 16

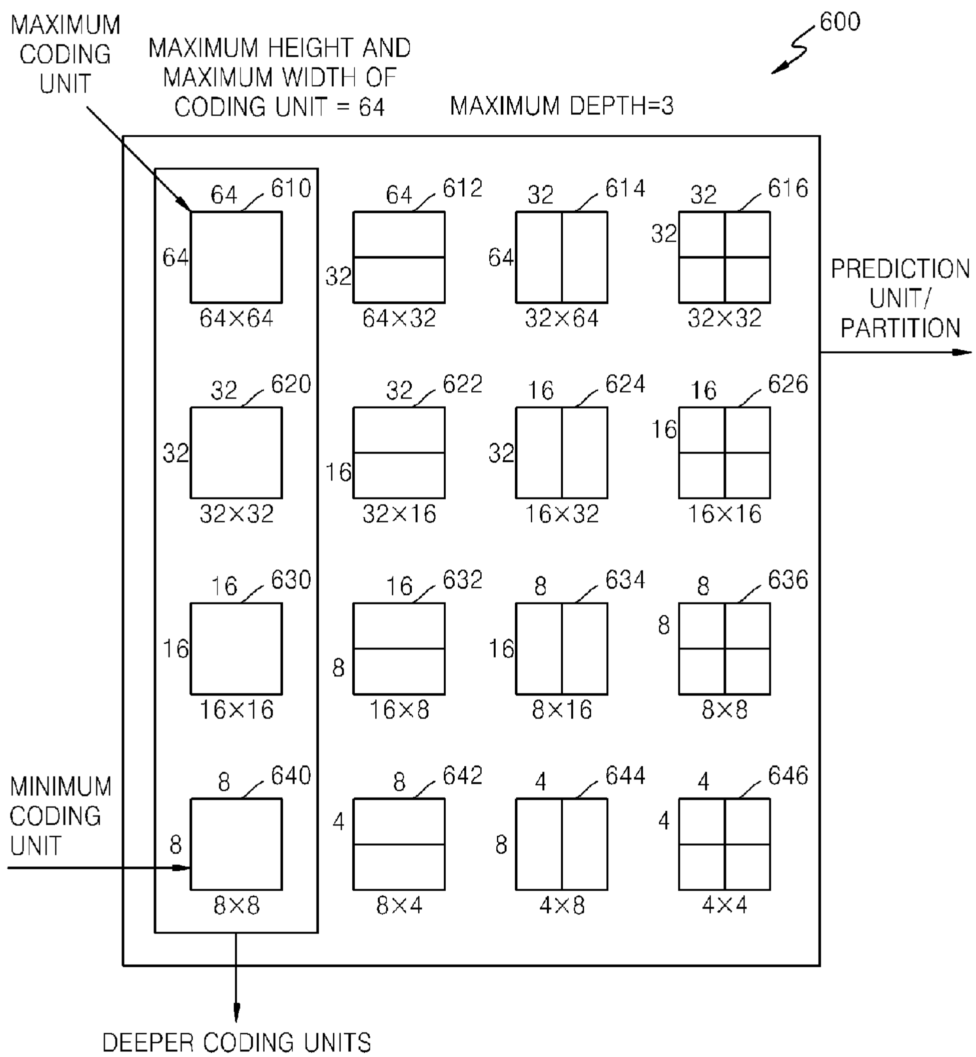

600
MAXIMUM CODING UNIT
MAXIMUM HEIGHT AND MAXIMUM WIDTH OF CODING UNIT = 64
MAXIMUM DEPTH=3
64
610
64
64×64
64
612
32
64×32
32
614
64
32×64
32
616
32
32×32
PREDICTION UNIT/ PARTITION
32
620
32
32×32
32
622
16
32×16
16
624
32
16×32
16
626
16
16×16
16
630
16
16×16
16
632
8
16×8
8
634
16
8×16
8
636
8
8×8
MINIMUM CODING UNIT
8
640
8
8×8
8
642
4
8×4
4
644
8
4×8
4
646
4
4×4
DEEPER CODING UNITS

FIG. 17

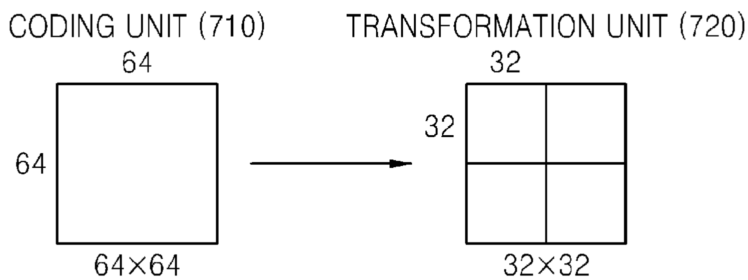

CODING UNIT (710)
TRANSFORMATION UNIT (720)
64
64
64×64
32
32
32×32

FIG. 18

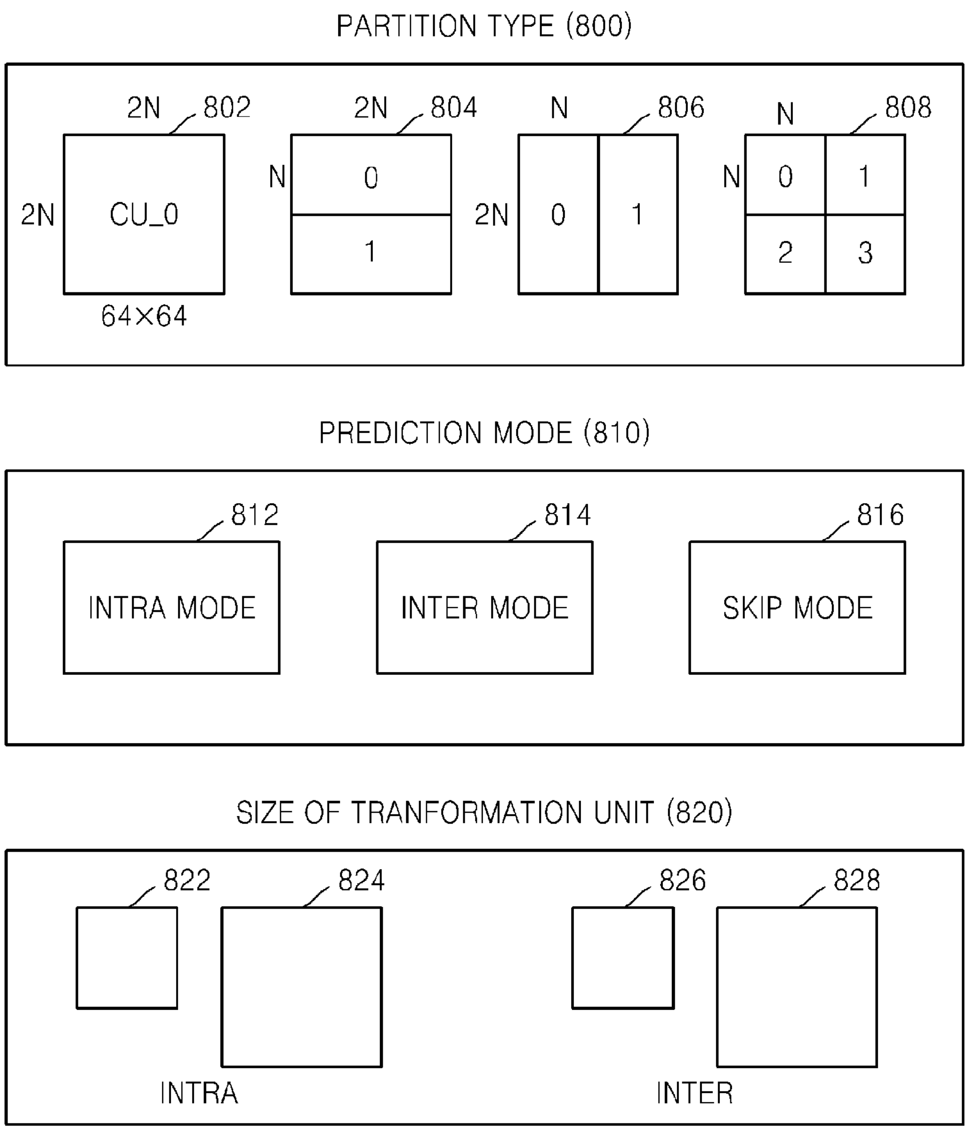

PARTITION TYPE (800)
2N
802
2N
CU_0
64×64
2N
804
N
0
1
N
806
2N
0
1
N
808
N
0
1
2
3
PREDICTION MODE (810)
812
INTRA MODE
814
INTER MODE
816
SKIP MODE
SIZE OF TRANFORMATION UNIT (820)
822
824
INTRA
826
828
INTER

FIG. 19

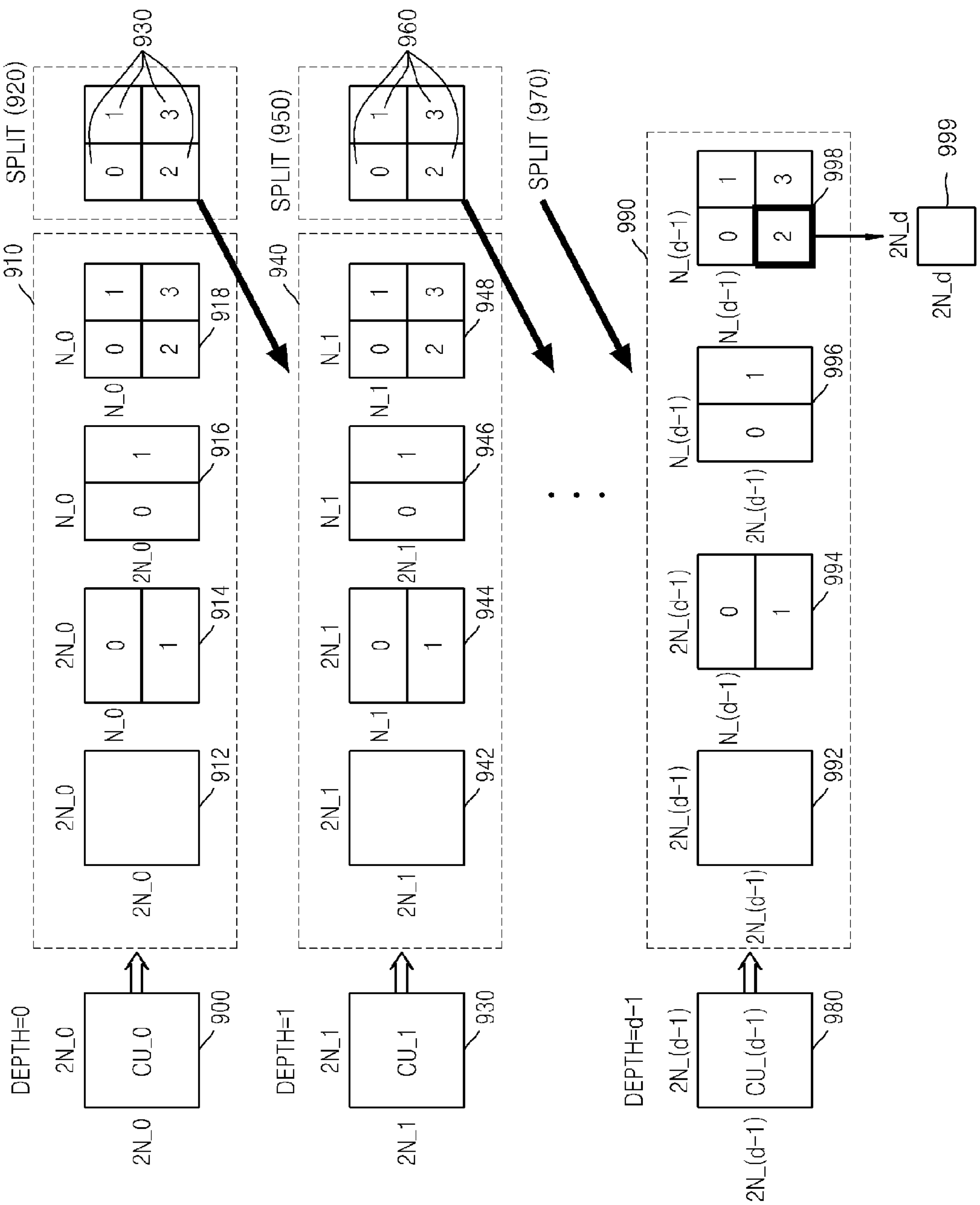
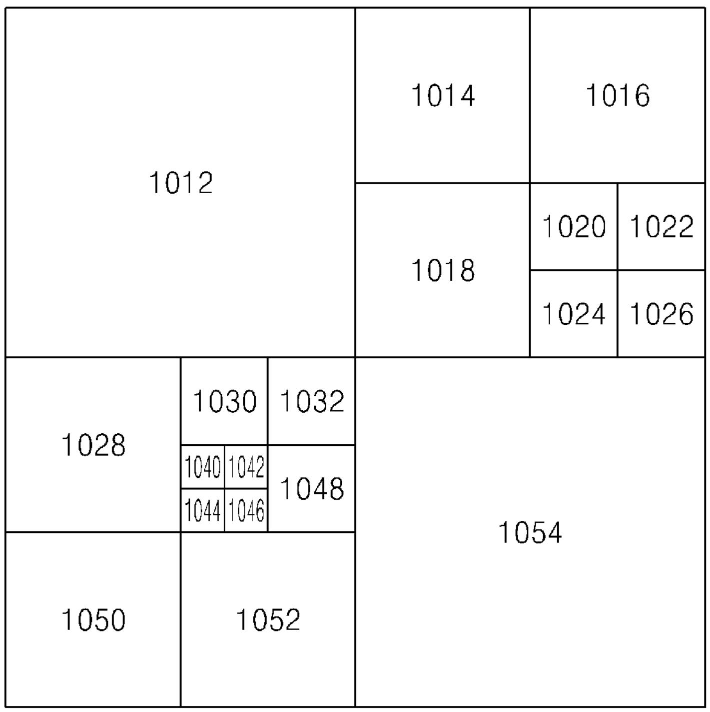

DEPTH=0
2N_0
2N_0
CU_0
900
910
2N_0
2N_0
912
N_0
2N_0
914
2N_0
N_0
916
N_0
N_0
918
SPLIT (920)
930
DEPTH=1
2N_1
2N_1
CU_1
930
940
2N_1
2N_1
942
N_1
2N_1
944
2N_1
N_1
946
N_1
N_1
948
SPLIT (950)
960
SPLIT (970)
DEPTH=d-1
2N_(d-1)
2N_(d-1)
CU_(d-1)
980
990
2N_(d-1)
2N_(d-1)
992
N_(d-1)
2N_(d-1)
994
2N_(d-1)
N_(d-1)
996
N_(d-1)
N_(d-1)
998
2N_d
2N_d
999

FIG. 20



CODING UNIT (1010)

FIG. 21

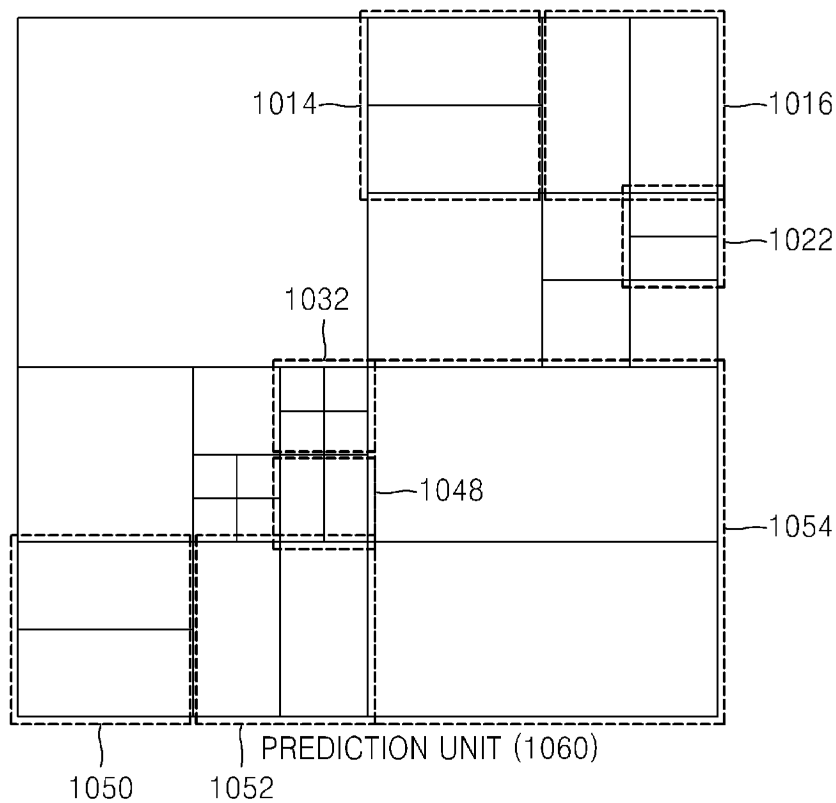

1014
1016
1022
1032
1048
1054
1050
1052
PREDICTION UNIT (1060)

FIG. 22

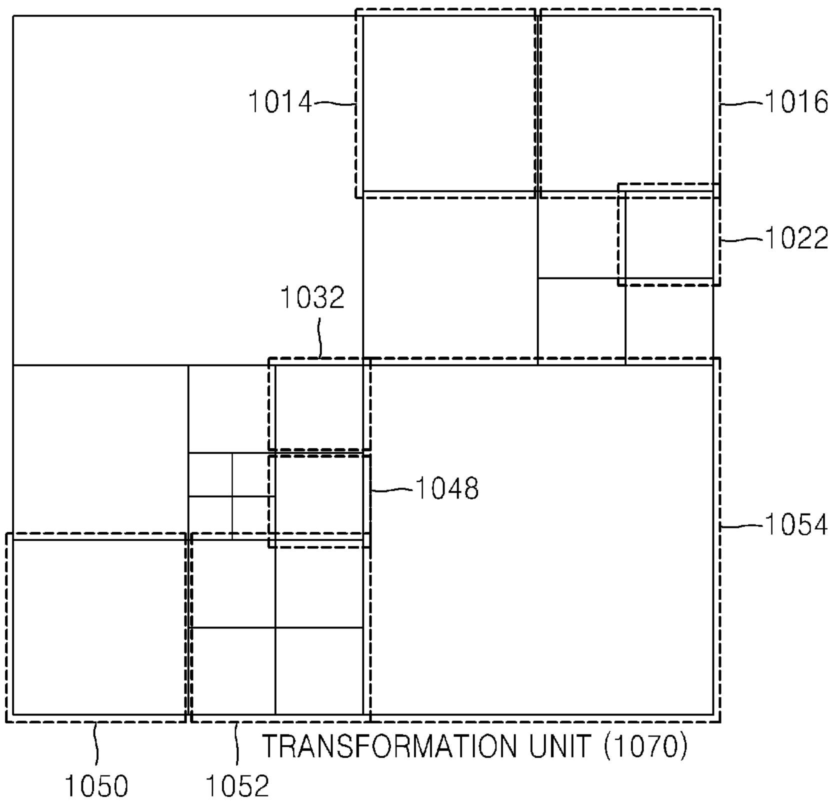
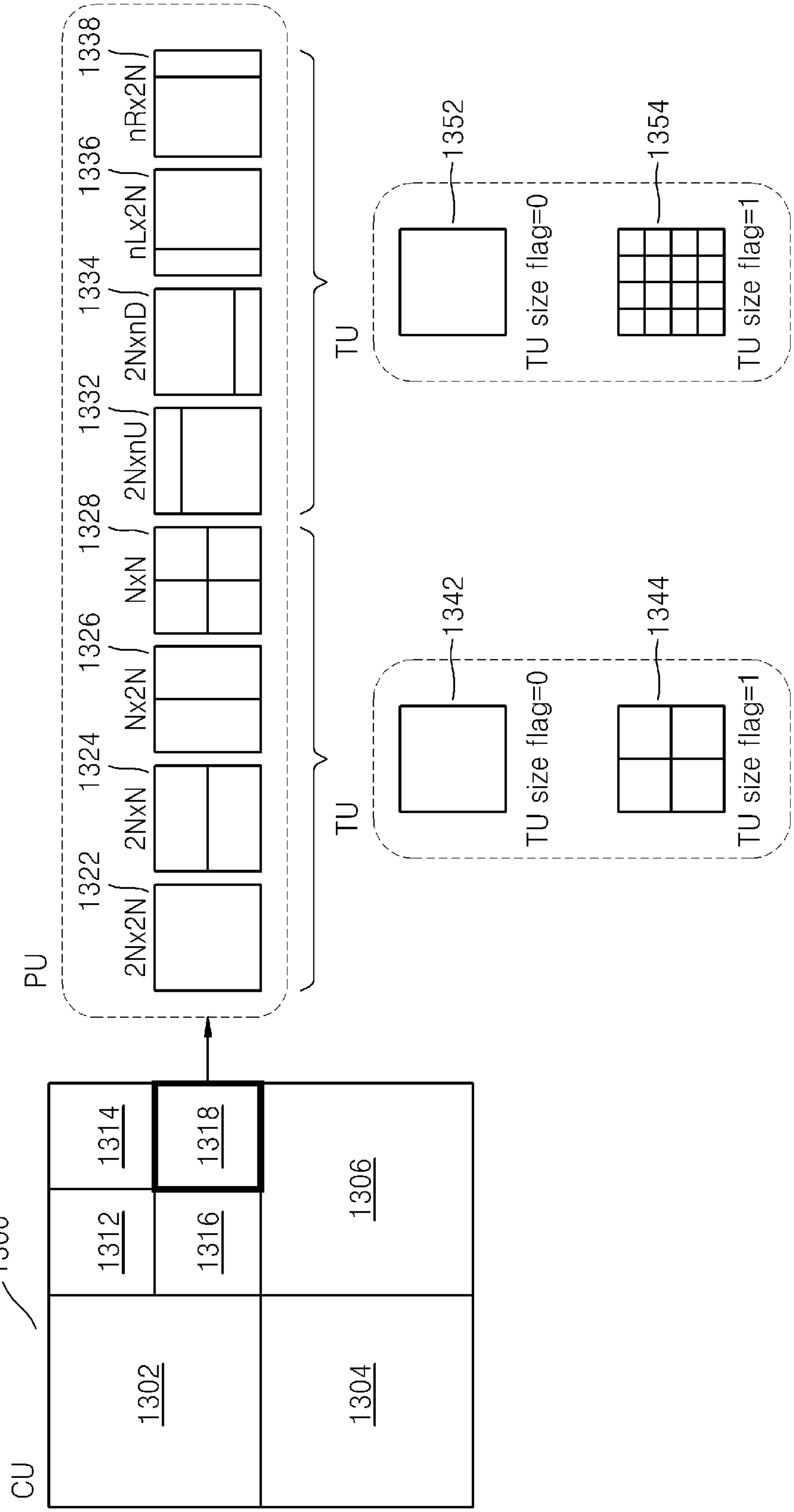

1014
1016
1022
1032
1048
1054
1050
1052
TRANSFORMATION UNIT (1070)

FIG. 23



CU
1300
1302
1304
1306
1312
1314
1316
1318
PU
2Nx2N
1322
2NxN
1324
Nx2N
1326
NxN
1328
2NxnU
1332
2NxnD
1334
nLx2N
1336
nRx2N
1338
TU
1342
TU size flag=0
1344
TU size flag=1
TU
1352
TU size flag=0
1354
TU size flag=1

METHOD AND APPARATUS FOR ENCODING VIDEO USING ADJUSTABLE LOOP FILTERING, AND METHOD AND APPARATUS FOR DECODING VIDEO USING ADJUSTABLE LOOP FILTERING

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a National Stage application under 35 U.S.C. §371 of International Application No. PCT/KR2011/004970, filed on Jul. 7, 2011, and claims the benefit of U.S. Provisional Application No. 61/362,789, filed on Jul. 9, 2010 in the United States Patent and Trademark Office, the disclosures of which are incorporated herein by reference in their entireties.

1. FIELD

[0002] Methods and apparatuses consistent with exemplary embodiments relate to a method and apparatus for encoding a video, and a method and apparatus for decoding a video.

2. DESCRIPTION OF RELATED ART

[0003] Due to development and supply of hardware capable of reproducing and storing video contents having a high resolution or a high image quality, the need for a video codec for effectively encoding or decoding the video contents having a high resolution or a high image quality is increasing. According to a conventional video codec, a video is encoded according to a limited encoding method based on a macroblock of a predetermined size. Also, a conventional video codec performs transformation and inverse transformation on macroblocks by using blocks having the same sizes to encode or decode video data.

SUMMARY

[0004] One or more exemplary embodiments provide a method and apparatus for encoding a video, and a method and apparatus for decoding a video.

[0005] According to an aspect of an exemplary embodiment, there is provided a method of decoding a video using a video decoding processor, the method including: extracting encoding information and encoded video data from a received bit stream; decoding the encoded video data for each coding unit of the video data using the encoding information; performing loop filtering on the decoded video data of each coding unit using internal pixels of the coding unit, based on a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit; and restoring the video by combining the decoded video data and the loop-filtered decoded video data on which the loop filtering is performed, for each coding unit.

[0006] According to an aspect of an exemplary embodiment, there is provided a method of encoding a video using a video encoding processor, the method including: encoding the video data based on a coding unit obtained by splitting a video data into spatial domains; performing loop filtering on the coding unit using internal pixels of the coding unit, based on a minimum distance between a pixel, on which loop filtering is to be performed, from among video data of the coding unit, and a border of the coding unit, and a filter length of the loop filter; and outputting encoding information related to an encoding method and the encoded video data for each of the coding units.

[0007] According to an aspect of an exemplary embodiment, there is provided a video decoding apparatus including: a receiving unit to that extracts encoding information and encoded video data from a received bit stream; an adaptive loop filter (ALF) coding unit that decodes the encoded video data for each coding unit of the video data using the encoding information, and performs loop filtering on the decoded video data of each coding unit using internal pixel values of the coding unit, based on (i) a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit, and (ii) a filter length of the loop filter; and a restoring unit that restores the video by combining the decoded video data and the loop-filtered decoded video data on which loop filtering is performed, for each of the coding units.

[0008] According to an aspect of an exemplary embodiment, there is provided a video encoding apparatus including: an ALF coding unit that performs loop filtering on a coding unit using internal pixel values of the coding unit, based on (i) a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit, and (2) a filter length of the loop filter, the coding unit obtained by splitting video data into spatial domains, and encodes video data for each of the coding units; and an output unit that outputs encoding information related to an encoding method and the encoded video data for each of the coding units.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The above and other aspects will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

[0010] FIG. **1** is a block diagram illustrating a video encoding apparatus using loop filtering according to an exemplary embodiment;

[0011] FIG. **2** is a block diagram illustrating a video decoding apparatus using loop filtering according to an exemplary embodiment;

[0012] FIG. **3** illustrates a filtering area of loop filtering for a 64×64 block;

[0013] FIG. **4** illustrates a loop filtering area determined according to an exemplary embodiment;

[0014] FIG. **5** illustrates a line memory area used for deblocking filtering and loop filtering for a current coding unit, according to an exemplary embodiment;

[0015] FIG. **6** illustrates a method of determining a loop filter according to an exemplary embodiment;

[0016] FIGS. **7** and **8** are a flowchart and diagram of a method of performing deblocking filtering and loop filtering with respect to a current coding unit according to a relationship between deblocking filtering and loop filtering according to an exemplary embodiment:

[0017] FIGS. **9** and **10** illustrate a loop filtering area determined according to another exemplary embodiment and a loop filtering area with respect to a current coding unit;

[0018] FIG. **11** is a flowchart illustrating a video encoding method using loop filtering according to an exemplary embodiment;

[0019] FIG. **12** is a flowchart illustrating a video decoding method using loop filtering according to an exemplary embodiment;

[0020] FIG. **13** is a diagram for describing a concept of coding units according to an exemplary embodiment;

[0021] FIG. **14** is a block diagram of an image encoder based on coding units according to an exemplary embodiment;

[0022] FIG. **15** is a block diagram of an image decoder based on coding units according to an exemplary embodiment;

[0023] FIG. **16** is a diagram illustrating deeper coding units according to depths, and partitions according to an exemplary embodiment;

[0024] FIG. **17** is a diagram for describing a relationship between a coding unit and transformation units, according to an exemplary embodiment;

[0025] FIG. **18** is a diagram for describing encoding information of coding units corresponding to a coded depth, according to an exemplary embodiment;

[0026] FIG. **19** is a diagram of deeper coding units according to depths, according to an exemplary embodiment;

[0027] FIGS. **20** through **22** are diagrams for describing a relationship between coding units, prediction units, and transformation units, according to an exemplary embodiment; and

[0028] FIG. **23** is a diagram for describing a relationship between a coding unit, a prediction unit or a partition, and a transformation unit, according to encoding mode information of Table 1.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0029] Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0030] In various exemplary embodiments, an "image" may be understood as an inclusive concept which refers to not only a still image but also a video. Also, in the various exemplary embodiments, a "data unit" refers to a set of data of a predetermined range from among data that constitutes a video.

[0031] Hereinafter, encoding and decoding of a video using loop filtering according to an exemplary embodiment will be described with reference to FIGS. **1** through **12**. Also, encoding and decoding of a video based on a data unit, such as a coding unit in accordance with a tree structure, will be described with reference to FIGS. **13** through **23**. To determine a data area in which the loop filtering described above with reference to FIGS. **1** through **12** is performed, the data unit to be described with reference to FIGS. **13** through **23** may be used.

[0032] FIG. **1** is a block diagram illustrating a video encoding apparatus **10** using loop filtering according to an exemplary embodiment.

[0033] The video encoding apparatus **10** using loop filtering includes an adaptive loop filter (ALF) coding unit **11** and an output unit **12**. For convenience of description, the video encoding apparatus **10** using loop filtering will be referred to as "video encoding apparatus **10**."

[0034] The video encoding apparatus **10** may be operated such that an internal video encoding processor mounted in the video encoding apparatus **10** is operated in connection with the ALF coding unit **11** and the output unit **12** or in connection with an external video processor so as to output a video encoding result, thereby performing video encoding including the loop filtering according to the current exemplary embodiment. The function of the internal video encoding processor of the video encoding apparatus **10** may be implemented not only by including an additional processor but also by using a video encoding processing module included in the ALF coding unit **11**, a central processing unit, or a graphic calculation unit to perform basic video encoding operations.

[0035] The ALF coding unit **11** may encode an input video based on coding units which are obtained by splitting video data into spatial domains. The coding units may include not only fixed macro-blocks but also coding units having a tree structure. The coding units having a tree structure will be described in detail below with reference to FIGS. **13** through **23**.

[0036] The ALF coding unit **11** may perform loop filtering in order to reduce error caused by encoding. The ALF coding unit **11** may perform loop filtering based on coding units.

[0037] The ALF coding unit **11** may perform loop filtering with respect to video data of a spatial domain that is restored by performing inverse quantization, inverse transformation, and motion compensation to a quantized transformation coefficient that is generated by performing motion estimation, transformation, and quantization to video data of a spatial domain. The ALF coding unit **11** may encode video data that is filtered by loop filtering, by performing motion estimation, transformation, and quantization again. Also, the quantized transformation coefficient may be output after performing variable length coding thereto.

[0038] The ALF coding unit **11** may determine a loop filtering method, based on a minimum distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit, and a border of the coding unit. Alternatively, the loop filtering method may be determined based on a filter length of a loop filter.

[0039] Also, the ALF coding unit **11** may determine a loop filtering method, based on a minimum distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit, and a border of the coding unit, and based on a filter length for loop filtering.

[0040] The loop filtering method may include a method in which a pixel on which loop filtering is to be performed, that is, a loop filtering area including a central pixel of loop filtering is determined and a method whereby a loop filter type is determined.

[0041] In an operation of performing filtering to a pixel within a current coding unit, neighbor pixels may be used or referred to depending on a filter type. If a neighbor pixel is stored in a different data storage space from a data storage space in which data that is currently encoded is stored, an operation delay may be generated to import data or an operation load may increase.

[0042] The ALF coding unit **11** may determine at least one of a loop filtering area and a loop filter such that an operation delay or an operation load caused while using a neighbor pixel may be minimized.

[0043] A position of a neighbor pixel used for filtering of a pixel in a current coding unit may be determined according to a filter length of a loop filter. For example, if a filter length of a loop filter is long, a neighbor pixel used for filtering of a pixel in a current coding unit may be located outside the current coding unit. While filtering regarding a pixel within a current coding unit is performed, if a neighbor pixel used in filtering is located outside the current coding unit, a filtering operation is likely to be delayed or an operation load is likely to increase.

[0044] Accordingly, the ALF coding unit **11** may determine a loop filtering method such that a pixel within a coding unit may be used in loop filtering with respect to a pixel of a current coding unit. The ALF coding unit **11** may determine a loop filtering method based on a distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit, and a nearest border from among borders of the coding unit, that is, a minimum distance, and based on a filter length of a loop filter.

[0045] For example, the ALF coding unit **11** may determine a loop filtering method based on a distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit, and closest borders from among upper and lower borders of the coding unit, that is, a minimum vertical distance, and based on a filter vertical length for filtering of a loop filter. The filter vertical length of a loop filter may denote the number of filter coefficients of the longest axis from among vertical filter coefficients of a loop filter that is to be applied to a current filtering area.

[0046] Similarly, the ALF coding unit **11** may also determine a loop filtering method based on a distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit, and closest borders from among left and right borders of the coding unit, that is, a minimum horizontal distance, and based on a filter horizontal length for filtering of a loop filter. The filter horizontal length of a loop filter may denote the number of filter coefficients of the longest axis from among horizontal filter coefficients of a loop filter that is to be applied to a current filtering area.

[0047] To determine a loop filter, a loop filter type, a filter length of a loop filter, and the like may be adjusted. A filter horizontal length and a filter vertical length of a loop filter may be individually determined. The filter vertical length of a loop filter may be determined to be shorter than the filter horizontal length. This is because when external data of a coding unit is used in vertical loop filtering with respect to a coding unit, an operation delay or an operation load significantly increases.

[0048] The ALF coding unit **11** may determine a loop filtering area within an internal area that is away from at least one border of a coding unit a predetermined distance based on the minimum distance between a pixel to be filtered and a border of a coding unit and on a filter length of a loop filter. For example, the predetermined distance from the at least one border of a coding unit to the internal area may be determined to be equal to or greater than the filter length of the loop filter.

[0049] A loop filtering area may be determined to be an area including pixels to be filtered by loop filtering.

[0050] A filtering area of loop filtering may include at least one of a first internal area separated from borders of a coding unit a predetermined distance, a second internal area separated from upper and lower borders of a coding unit a predetermined distance, and a third internal area separated from a lower border of a coding unit a predetermined distance.

[0051] Selectively, a filtering area of loop filtering may further include a fourth internal area that is separated from at least one of an upper border and a lower border of a coding unit a first distance and that is separated from at least one of a left border and a right border of the coding unit a second distance.

[0052] The ALF coding unit **11** may determine a loop filter such that a filter length of the loop filter is smaller than or equal to a minimum distance between a pixel to be filtered and a border of a coding unit.

[0053] The ALF coding unit **11** may determine a loop filtering area based on a minimum distance between a pixel to be filtered and a border of a coding unit, and determine a filter length of a loop filter based on a minimum distance between pixels of the determined loop filtering area and a border of a coding unit.

[0054] For example, the ALF coding unit **11** may determine a loop filtering area based on a minimum vertical distance between a current filter and an upper or lower border of a current coding unit, and determine a filter vertical length of a loop filter based on the minimum vertical distance between pixels of the loop filtering area and an upper border or a lower border of a coding unit.

[0055] The ALF coding unit **11** may determine a loop filter based on a minimum distance between a pixel to be filtered and a border of a coding unit, and determine a loop filtering area within an internal area that is separated from at least one border of a coding unit the previously determined filter length of a loop filter.

[0056] For example, the ALF coding unit **11** may determine a filter vertical length of a loop filter based on a minimum vertical distance between a pixel of a current coding unit and an upper border or a lower border of the current encoding unit, and determine a loop filtering area within an internal area that is away from at least one border of a coding unit the vertical filter length of the loop filter.

[0057] The ALF coding unit **11** may perform loop filtering to a current coding unit by using the loop filtering area and the loop filter that are determined based on the minimum distance between the pixel to be filtered and the border of the coding unit.

[0058] By associating deblocking filtering and loop filtering with each other, the ALF coding unit **11** may determine a loop filtering method in consideration of a deblocking filtering area. The ALF coding unit **11** may determine a loop filtering method for a current coding unit in consideration of a deblocking filtering area in which data is to be modified by prospective deblocking filtering, from among pixels of a current coding unit.

[0059] The ALF coding unit **11** may determine a filtering area or a loop filter such that deblocking filtering and loop filtering are not repeatedly performed on pixels of a current coding unit. Accordingly, the ALF coding unit **11** may determine a filtering area or a loop filter based on a minimum distance between a pixel in a current coding unit and a border of a coding unit, a filter length of a loop filter, and a height of a deblocking filtering area. A deblocking filtering area refers to an area of pixels in which data is modified by prospective deblocking filtering from among internal pixels of the current coding unit.

[0060] For example, the ALF coding unit **11** may determine a loop filtering area based on a minimum distance between a pixel in a current coding unit and upper and lower borders of a coding unit, a filter vertical length of a loop filter, and a height of a deblocking filtering area. Also, the ALF coding unit **11** may determine a filter vertical length of a loop filter based on the minimum distance between a pixel in a current coding unit and upper and lower borders of a coding unit and a height of a deblocking filtering area.

[0061] For example, the ALF coding unit **11** may determine a loop filtering area from among areas except the deblocking filtering area in which data is modified by deblocking filtering within a current coding unit.

[0062] Also, the ALF coding unit **11** may determine a filtering area or a filter length of a loop filter such that external pixels of the current coding unit may be used if an operation delay or an operation load does not increase even when external pixels outside borders of a coding unit are used for filtering of a pixel within the current coding unit.

[0063] For example, loop filtering may be performed by using accessible pixels for deblocking filtering with respect to a predetermined pixel unit, from among pixels outside the upper or lower border of the current coding unit. Accordingly, the ALF coding unit **11** may extend at least one of the loop filtering area and the filter vertical length of the determined loop filter and determine the same based on the number of neighbor pixels used for deblocking filtering with respect to a current coding unit in a vertical direction.

[0064] The number of neighbor pixels used for deblocking filtering with respect to a current coding unit in a vertical direction is determined based on a vertical length of a deblocking filter, and accordingly, at least one of the loop filtering area and the filter vertical length of the determined loop filter may be extended based on a vertical length of a deblocking filter.

[0065] The ALF coding unit **11** may determine a loop filter within a current coding unit. Alternatively, the ALF coding unit **11** may determine a loop filter with respect to a pixel based on pixel positions in a coding unit. The pixel positions may be classified based on a distance between a pixel and a predetermined border of a coding unit. For example, a filter vertical length may be determined to be smaller as the minimum distance between a current pixel and the upper and lower borders of a coding unit narrows, and to be greater as the minimum distance expands. Alternatively, the ALF coding unit **11** may determine at least two loop filters within a predetermined data unit in order to adjust a bandwidth for data transmission needed for loop filtering. The ALF coding unit **11** may determine at least two loop filters for each coding unit. Also, the ALF coding unit **11** may determine at least two loop filters in consideration of the overall characteristics of a frame comprising the current coding unit.

[0066] A loop filter type or a filter length of a loop filter may be modified according to the determined loop filter. For example, a loop filter type such as a forward filter, a diamond type filter, a polygonal filter, or a one-dimensional filter may be selected, or a filter length of a loop filter such as a 9-tap, 7-tap, 5-tap, or 3-tap filter may be selected.

[0067] The ALF coding unit **11** may determine at least two loop filters such that loop filters which differ in regard to at least one of a loop filter type and a filter length are combined for each of predetermined data units.

[0068] The ALF coding unit **11** may determine a plurality of loop filters which are different in terms of filter type, for loop filtering for a current data unit. For example, a square filter and a diamond-shaped filter may be selected as loop filters for a current data unit, or three types of loop filters, that is, a diamond-shaped filter, a polygonal filter, and a one-dimensional filter may be used at the same time.

[0069] Also, the ALF coding unit **11** may determine a plurality of loop filters which are different in terms of a filter length of a loop filter, for loop filtering for a current data unit. For example, a 3-tap loop filter and a 7-tap loop filter may be selectively determined to be used according to a border area or an internal area of a data unit. Alternatively, three types of loop filters may be determined to be used at the same time such that 3-tap and 5-tap loop filters may be selectively used according to border directions within a border area, and a 9-tap loop filter may be used in an internal area.

[0070] Also, the ALF coding unit **11** may determine a plurality of loop filters which are different both in terms of loop filter type and filter length, for loop filtering on a current data unit. For example, as loop filters for a current data unit, a 5-tap loop filter may be used in an internal area of a coding unit, and for a border area, two types of loop filters may be determined to be used, that is, diamond-shaped loop filters, one having a filter vertical length of 7-tap and the other having a filter horizontal length of 9-tap may be determined to be used.

[0071] Similarly to the above-described loop filter determining method, when the ALF coding unit **11** determines a plurality of loop filters for loop filtering with respect to a current data unit, different loop filters may be determined according to positions of filtering areas.

[0072] An output unit **12** outputs video data encoded for each coding unit and encoding information related to an encoding method based on the coding unit. The encoding information may include encoding mode information needed in decoding the encoded video data based on the coding unit. Bit streams of the encoded video data and the encoding information may be included in at least one output bit stream.

[0073] The output unit **12** may transmit filter coefficients for loop filtering as encoding information. Also, the output unit **12** may transmit encoding information regarding a loop filtering method for signaling whether loop filtering is allowed, whether modification of a loop filtering area is allowed, whether modification of a loop filter is allowed, whether modification of the loop filtering method is allowed, or whether loop filtering may be overlapped with deblocking filtering.

[0074] If the video encoding apparatus **10** encodes data based on coding units having a tree structure, the ALF coding unit **11** may split a picture to a maximum coding unit, which is a data unit of the largest size for encoding, determine coding units having a tree structure including the maximum coding unit, and output video data that is encoded for each coding unit.

[0075] The ALF coding unit **11** may perform loop filtering on a predetermined coding unit included in the coding units having a tree structure. For example, loop filtering may be performed on the maximum coding unit. Alternatively, loop filtering may be performed on coding units having a size equal to or greater than a predetermined size from among coding units having a tree structure.

[0076] If the video encoding apparatus **10** encodes data based on coding units having a tree structure, the output unit **12** may output, together with data encoded for each coding unit, information about a maximum size of a coding unit, information about variable depth range, structure information needed to determine coding units having a tree structure, encoding information about an encoding mode for decoding encoded video data, and information about loop filtering.

[0077] FIG. **2** is a block diagram illustrating a video decoding apparatus **20** using loop filtering according to an exemplary embodiment.

[0078] The video decoding apparatus **20** according to an exemplary embodiment using loop filtering includes a receiving unit **21**, an ALF decoding unit **22**, and a restoring unit **23**. For convenience of description, the video decoding apparatus **20** using loop filtering will be referred to as a "video decoding apparatus **20**."

[0079] To restore encoded video by decoding, the video decoding apparatus **20** may perform a video decoding operation including loop filtering as a video decoding processor mounted in the video decoding apparatus **20** and the receiving unit **21**, the ALF decoding unit **22**, and the restoring unit **23**

operate in connection with one another, or as an external video decoding processor and the three elements operate in connection with one another. The function of internal video decoding processor of the video decoding apparatus **20** may be implemented not only by including an additional video decoding processor but also by using a video decoding processing module included in the ALF decoding unit **22**, a central processing unit or a graphic calculation device to perform basic video decoding operations.

[0080] The receiving unit **21** extracts decoding information including information about an encoding mode for decoding encoded video data and encoded video data, by receiving and parsing a bit stream of a video.

[0081] The video decoding apparatus **20** may receive a bit stream of encoded video based on coding units which are obtained by splitting video data to spatial domains. The coding units may include not only fixed macro-blocks but also coding units having a tree structure, which will be described later with reference to FIGS. **13** through **23**.

[0082] When the video decoding apparatus **20** receives a bit stream of encoded video based on coding units having a tree structure, the receiving unit **21** may parse and extract from the bit stream the encoded video data and information about a maximum size of coding units, information about variable ranges of a depth, structure information for determining coding units having a tree structure, and encoding information about encoding modes for decoding encoded video based on the coding units having a tree structure.

[0083] The ALF decoding unit **22** may receive the encoding information and the video data extracted by using the receiving unit **21**, and may decode encoded video data for each coding unit by using the encoding information.

[0084] The ALF decoding unit **22** may perform variable length decoding, inverse quantization, inverse transformation, and motion compensation on the encoded video data by using an encoding mode read from the encoding information, thereby generating video data of a spatial domain. A quantized transformation coefficient is output by variable length decoding, and the quantized transformation coefficient may be output as motion data of an original video is restored through inverse quantization and inverse transformation. Motion data of an original video may be restored to video data of a spatial domain by motion compensation.

[0085] The restoring unit **23** may restore pictures by combining decoded video data of a spatial domain to restore a video.

[0086] The ALF decoding unit **22** may perform loop filtering on decoded video data of a spatial domain in order to reduce error caused by encoding and decoding. The ALF decoding unit **22** may perform loop filtering based on coding units of decoded video data.

[0087] The ALF decoding unit **22** may determine a loop filtering method such that pixel values in a coding unit are used based on a minimum distance between a pixel on which loop filtering is to be performed and a border of a coding unit and based on a filter length of a loop filter.

[0088] For example, the ALF decoding unit **22** may determine a loop filtering method based on a minimum distance between a pixel on which loop filtering is to be performed and upper and lower borders of a coding unit and a filter vertical length of a loop filter. Similarly, the ALF decoding unit **22** may determine a loop filtering method based on a minimum distance between a pixel on which loop filtering is to be performed and left and right borders of a coding unit and a filter horizontal length of a loop filter.

[0089] As the loop filtering method, a loop filtering area and a loop filter may be determined. The ALF decoding unit **22** may perform loop filtering on a coding unit by using the loop filtering area or the loop filter determined based on a minimum distance between a pixel on which loop filtering is to be performed and a border of a coding unit, and based on a filter length of a loop filter.

[0090] The ALF decoding unit **22** may determine a loop filtering area within an internal area that is away from at least one border of a coding unit a predetermined distance, based on a minimum distance between a pixel on which loop filtering is to be performed and a border of a coding unit.

[0091] For example, the ALF decoding unit **22** may determine a loop filtering area within an internal area away from at least one border of a coding unit a predetermined distance based on a minimum distance between a pixel and an upper border or a lower border of a coding unit and a filter vertical length. The predetermined distance between at least one border of a coding unit and an internal area of the coding unit may be equal to or greater than a filter vertical length.

[0092] The loop filtering area determined may include at least one of a first internal area separated from borders of a coding unit a predetermined distance, a second internal area separated from upper and lower borders of a coding unit a predetermined distance, and a third internal area separated from a lower border of a coding unit a predetermined distance.

[0093] Also, the ALF decoding unit **22** may determine a loop filter such that a filter length for loop filtering is equal to or smaller than a minimum distance between a pixel and a border of a coding unit. For example, the ALF decoding unit **22** may determine a loop filter such that a filter vertical length for vertical filtering of a loop filter is equal to or smaller than a minimum vertical distance between a pixel in a coding unit and upper and lower borders of a coding unit.

[0094] Also, a filter vertical length of a loop filter according to an embodiment may be determined to be smaller than a filter horizontal length.

[0095] The ALF decoding unit **22** may determine a loop filtering area based on a minimum distance between a pixel of a current coding unit and a border of a coding unit, and determine a filter length of a loop filter based on a minimum distance between a pixel of the determined loop filtering area and a border of a coding unit.

[0096] For example, the ALF decoding unit **22** may determine a loop filtering area based on a minimum distance between a pixel of a current coding unit and upper and lower borders of a coding unit, and determine a filter vertical length of a loop filter based on a minimum distance between a pixel of the determined loop filtering area and a border of a coding unit.

[0097] The ALF decoding unit **22** may determine a filter length of a loop filter based on the minimum distance between a pixel in a coding unit and a border of a coding unit, and determine a loop filtering area in an internal area away from at least one border of a coding unit the filter length determined above.

[0098] For example, the ALF decoding unit **22** may determine a filter vertical length of a loop filter based on the minimum distance between a pixel in a coding unit and upper and lower borders of a coding unit, and determine a loop filtering area in an internal area away from at least one border of a coding unit the filter vertical length determined above.

[0099] The ALF decoding unit **22** may perform loop filtering by using the loop filtering area and the loop filter that are adjusted together based on the minimum distance between a pixel of a current decoding unit and a border of a coding unit.

[0100] The ALF decoding unit **22** may determine a loop filtering method with respect to a current coding unit in consideration of a deblocking filtering area from among internal area of the current coding unit.

[0101] The ALF decoding unit **22** may determine a loop filtering area or a filter vertical length of a loop filter based on a minimum vertical distance between a pixel of a current coding unit and upper and lower borders of a coding unit, and a height of a deblocking filtering area. A deblocking filtering area refers to an area of pixels in which data is to be modified by prospective deblocking filtering in the current coding unit.

[0102] The ALF decoding unit **22** may determine a loop filtering area in the coding unit except the deblocking filtering area.

[0103] For example, the ALF decoding unit **22** may determine a loop filtering area based on a minimum vertical distance between a pixel of a current coding unit and upper and lower borders of a coding unit and a filter vertical length of a loop filter, and may exclude at the same time a deblocking filtering area adjacent to the upper and lower borders of the coding unit from among pixels in the coding unit.

[0104] The ALF decoding unit **22** may extend a loop filtering area or a filter length of a loop filter by using neighbor pixels for deblocking filtering with respect to a current coding unit.

[0105] For example, the ALF decoding unit **22** may extend a loop filtering area or a filter vertical length of a loop filter based on a minimum vertical distance between a pixel of a current coding unit and an upper border or a lower border of a coding unit such that pixels in a coding unit are used, and such that currently accessible pixels from among external pixels of a coding unit may be used. The currently accessible pixels from among external pixels of a coding unit may be determined based on a filter vertical length of a deblocking filter of a predetermined coding unit, and thus, a loop filtering area or a filter vertical length of a loop filter may be extended based on a filter vertical length of a deblocking filter of a predetermined coding unit to be determined.

[0106] The ALF decoding unit **22** may determine a loop filter within a current coding unit. Alternatively, the ALF decoding unit **22** may determine a loop filter regarding each pixel based on pixel positions in a coding unit. The pixel positions may be classified based on a distance between a pixel and a predetermined border of a coding unit. For example, a filter vertical length may be determined to be smaller as the minimum distance between a current pixel and the upper and lower borders of the coding unit narrows, and to be greater as the minimum distance expands.

[0107] Alternatively, the ALF decoding unit **22** may determine at least two loop filters within a predetermined data unit. The ALF decoding unit **22** may determine at least two loop filters for each coding unit or for the whole frame comprising a current coding unit.

[0108] The ALF decoding unit **22** may determine at least two loop filters, which are different in regard to at least one of a loop filter type and a filter length, are combined for each predetermined data unit.

[0109] For example, the ALF decoding unit **22** may determine a plurality of loop filters which are different in terms of loop filter type, for loop filtering with respect to a current data unit. Also, the ALF decoding unit **22** may determine a plurality of loop filters which are different in terms of filter length, for loop filtering for a current data unit. Also, the ALF decoding unit **22** may determine a plurality of loop filters which are different in regard to both loop filter type and filter length. Similarly to the above-described loop filter determining method, when the ALF decoding unit **22** determines a plurality of loop filters for loop filtering with respect to a current data unit, different loop filters may also be respectively determined based on positions of filtering areas.

[0110] The ALF decoding unit **22** may determine a loop filter by using filter coefficients for loop filtering, which are extracted by the receiving unit **21**. Also, the ALF decoding unit **22** may read and determine whether to allow loop filtering, whether to allow modification of a loop filtering area, whether to allow modification of a loop filter, whether to allow modification of the loop filtering method, or whether to allow overlapping of loop filtering and deblocking filtering, and may also determine whether to perform loop filtering and a loop filtering method.

[0111] As described above, the ALF decoding unit **22** may directly determine a loop filtering method based on a minimum distance between a pixel and a border of a coding unit and a length of a loop filter, during a decoding operation of pixels of a current coding unit.

[0112] According to another exemplary embodiment, when information regarding a loop filtering method, which is extracted as encoding information includes loop filtering method information determined for each coding unit, the ALF decoding unit **22** may determine a loop filtering area or a loop filter based on loop filtering method information regarding a current coding unit that is read from the encoding information.

[0113] The restoring unit **23** may combine decoded video data that is decoded for each coding unit and data on which loop filtering is performed by using the ALF decoding unit to restore and output a video.

[0114] Accordingly, the video decoding apparatus **20** may determine a filtering area or a filter type of loop filtering such that maximum accessible data may be used while minimizing an operation delay or an operation load, and accordingly, the video decoding apparatus **20** may reduce encoding error by performing loop filtering based on a coding unit.

[0115] FIG. **3** illustrates a filtering area of loop filtering for a 64×64 block.

[0116] For blockwise encoding and decoding of a video, filtering is performed on each block with respect to video data of a spatial domain that is split to 64×64 blocks **30**.

[0117] For block-wise filtering according to the conventional loop filtering method, when a filter vertical length L1 and a filter horizontal length L2 are used, in order that blocks of a height MO and a width NO are output as a filtering result, a height MI of an input block is a sum of the height MO of an output block and a half L1/2 of the filter vertical length L1 (MI=MO+L1/2), and a width NI of the input block is a sum of a width NO of an output block and a half of the filter horizontal length L2/2 (NI=NO+L2/2).

[0118] For example, when a 9×9 size filter is used for loop filtering of a current block **31** of a 64×64 size, and when an input block **32** of conventional loop filtering is a 68×68 size block, a 64×64 size block may be output as a result of loop filtering.

[0119] Accordingly, data of an area **33** except the current block **31** of a 64×64 size from among the input block **32** during the encoding operation of the current block **31** becomes data outside the current block **31**. That is, for loop filtering of the current block **31**, data of an external data area **33** is used.

[0120] In general, during an encoding operation of the current block **31**, data of the current block **31** is stored in a data storage space such as a memory or a buffer which is easily accessible. Accessibility to data in a data storage space may be determined based on whether an operation delay is generated to import data or whether the amount of operation load is large.

[0121] If data of the external data area **33** that is needed for filtering of the current block **31** is not stored in a memory or a buffer which is easily accessible, an operation delay for filtering of the current block **31** may be generated, or an operation load may greatly increase.

[0122] FIG. **4** illustrates a loop filtering area determined according to an exemplary embodiment.

[0123] The video encoding apparatus **10** and the video decoding apparatus **20** may perform loop filtering on each of coding units **40**.

[0124] The video encoding apparatus **10** and the video decoding apparatus **20** may determine a loop filtering area from among an internal area of a coding unit based on a minimum distance between a pixel of each of current coding units and a border of a coding unit. A loop filtering area may be determined to be an area including pixels that are separated from at least one border of a coding unit a predetermined length, from among internal pixels of a coding unit. The predetermined length may be equal to or greater than a filter length of a loop filter.

[0125] For example, when a current coding unit **41** is a coding unit of a 64×64 size, and a filter length of a loop filter is 9 both in vertical and horizontal directions, a loop filtering area **42** may be determined as an area including pixels that are separated away from each border of the current coding unit **41** a half of a minimum filter length, that is, 4, from among internal pixels of the current coding unit **41**.

[0126] As a filtered pixel of the loop filtering area **42** is substantially output by loop filtering of the current coding unit **41**, the current coding unit **41** may be renewed by the loop filtering.

[0127] FIG. **5** illustrates a line memory area used for deblocking filtering and loop filtering for current coding units, according to an exemplary embodiment.

[0128] When the current frame **50** is encoded or decoded, from among a current coding unit **51**, pixels which are on the same line as pixels **54** may be renewed by loop filtering with respect to a current loop filtering area **52**, and pixels on the same line as pixels **55** may be renewed by prospective deblocking filtering.

[0129] To perform loop filtering of the current loop filtering area **52** which is currently decoded, all of pixels stored in a line memory **53** which are on the same line with neighboring pixels that are referred to during loop filtering have to be imported, including lines to which the pixels **54** and **55** belong. Accordingly, for loop filtering, when data stored in a line memory other than a currently easily accessible data space is used, an operation delay or an operation load may greatly increase.

[0130] FIG. **6** illustrates a method of determining a loop filter according to an exemplary embodiment.

[0131] The video encoding apparatus **10** and the video decoding apparatus **20** may adjust a type of a loop filter **62** or a filter length of the loop filter **62** in order to determine the loop filter **62** for loop filtering of each coding unit **61**.

[0132] The loop filter **62** may be a square shaped filter in which a filter vertical length and a filter horizontal length are identical, but may also be various polygonal filters such as a rectangular filter, a rhombic filter, or a diamond-shaped filter.

[0133] Also, a filter vertical length **64** and a filter horizontal length **65** of the loop filter **62** may be determined, respectively. For example, the filter vertical length **64** may be shorter than the filter horizontal length **65**.

[0134] A loop filtering area **63** may be determined in the coding unit **61** based on the shape of the determined loop filter **62**. When loop filtering is performed by using an external pixel of a current coding unit according to the filter vertical length **64** or the filter horizontal length **65** of the loop filter **62**, the loop filtering area **63** may be determined such that an additional calculation amount which may be generated to import data from a memory in which external pixels are stored.

[0135] For a similar purpose, if the loop filtering area **63** is determined in advance in a current coding unit, the filter vertical length **64** or the filter horizontal length **65** of the loop filter **62** may be determined based on the loop filtering area **63**.

[0136] When an external pixel is used for loop filtering with respect to the current coding unit **61**, external pixels at left and right borders of the current coding unit **61** may be stored in the same line memory as pixels of the current coding unit **61**, but external pixels at upper and lower borders of the current coding unit **61** are stored in an additional line memory. Accordingly, since a delay is likely to occur when approaching the external pixels at the upper and lower borders rather than the external pixels at the left and right borders of the current coding unit **61**, the filter vertical length **64** may preferably be shorter than the filter horizontal length **65**.

[0137] An additional calculation amount generated when using external pixels of the current coding unit **61** in horizontal loop filtering is not relatively large, and thus, according a loop filtering determining method of another exemplary embodiment, adjustment of widths of the filter horizontal length **65** of the loop filter **62** and the loop filtering area **63** may be omitted in connection with loop filtering of the current coding unit **61**. That is, for loop filtering of the current coding unit **61**, only the filter vertical length **64** of the loop filter **62** or a height of the loop filtering area **63** may be selectively adjusted based on a minimum vertical distance from a pixel of the current coding unit **61** to upper and lower borders thereof.

[0138] FIGS. **7** and **8** are a flowchart and diagram illustrating a method of performing deblocking filtering and loop filtering with respect to current coding units according to a relationship between deblocking filtering and loop filtering according to an exemplary embodiment.

[0139] While performing loop filtering to reduce various errors, which may occur by encoding and decoding operations such as prediction encoding, quantization, motion estimation, or the like, the video encoding apparatus **10** and the video decoding apparatus **20** may perform deblocking filtering to reduce block artifacts, which may occur by video encoding and decoding in block units, such as coding units.

[0140] The video encoding apparatus **10** and the video decoding apparatus **20** may select a filtering method such that deblocking filtering and loop filtering are not overlapped with respect to pixels of a current coding unit.

[0141] Coding units having a tree structure may include prediction units and transformation units for prediction and transformation, respectively. The relationship between coding units having a tree structure and the prediction units and the transformation units will be described later with reference to FIGS. **13** through **23**.

[0142] Deblocking filtering may be performed not only on borders of a coding unit but also on borders of a prediction unit and a transformation unit included in the coding unit. However, when deblocking filtering is performed on borders of the prediction unit and the transformation unit included in the coding unit, the deblocking filtering may be overlapped with loop filtering of a loop filtering area in the coding unit, and thus, a deblocking filtering method and a loop filtering method may be selectively determined.

[0143] An operation in which the video decoding apparatus **20** determines a filtering method for each coding unit is described with reference to the flowchart of FIG. **7**, and a filtering method for each operation will be described in detail with reference to FIG. **8**.

[0144] In operation S**70**, filtering of a current coding unit CU **81** is started.

[0145] In operation S**71**, from among loop filtering relevant information extracted by parsing a bit stream, an ALF flag indicating whether loop filtering of the current coding unit CU **81** is allowed is read to determine whether to perform loop filtering on the current coding unit CU **81**. The ALF flag may be a binary value having the value of "1" to indicate that loop filtering of the current coding unit CU **81** is allowed, and may have a value of "0" to indicate that the loop filtering of the current coding unit CU **81** is not allowed. When loop filtering of the current coding unit CU **81** is allowed, the method proceeds to S**72**, and if not allowed, the method proceeds to S**74**.

[0146] In operation S**72**, deblocking filtering may be performed only on a border of the current coding unit CU **81**, and in operation S**73**, loop filtering on the current coding unit CU **81** may be performed.

[0147] For example, deblocking filtering may be performed on a border of at least a 16×16 size data unit. In operation S**72**, deblocking filtering may be performed only on a border of the current coding unit **81**.

[0148] In operation S**73**, when a filtering vertical length and a filter horizontal length of a loop filter are each 9, an 56×56 size internal area that is away from each of upper, lower, left, and right borders of the current coding unit CU **81** four pixels may be determined as a loop filtering area **83**. Also, loop filtering may be performed in areas except pixels whose values are modified by deblocking filtering within a coding unit from among pixels that are adjacent to borders in the internal area of the current coding unit CU **81**.

[0149] When a maximum of four internal pixels are modified from a border pixel are modified in a vertical direction by deblocking filtering on the current coding unit CU **81**, a 56×56 size loop filtering area **83** that is determined by a current loop filter length may be maintained. If more than five internal pixels are modified in a direction vertical to the border pixel by deblocking filtering, the loop filtering area **83** may be reduced to be smaller than a 56×56 size.

[0150] In operation S**74**, with respect to the current coding unit **81**, deblocking filtering may be performed not only on borders of a coding unit but also on borders of prediction units PUs and transformation units TUs included in the coding unit.

[0151] For example, deblocking filtering may be performed on a border of a data unit having a size of at least a 16×16 size, and thus, together with deblocking on borders of the current coding unit CU **81**, deblocking filtering on borders of prediction units and transformation units of a size larger than a 16×16 size from among prediction units and transformation units included in the current coding unit CU **81** may be performed. In this case, however, loop filtering on internal pixels of the current coding unit CU **81** may be skipped.

[0152] FIGS. **9** and **10** illustrate a loop filtering area **92** determined according to another exemplary embodiment and a loop filtering area with respect to a current coding unit **91**.

[0153] Referring to FIGS. **9** and **10**, vertical loop filtering is adjusted considering that accessibility to a line memory in which external pixels on upper and lower borders of the current coding unit **91** is lower than accessibility to a line memory in which external pixels on left and right borders thereof. That is, a height of the loop filtering area **92** may be adjusted, and a filter vertical length of a loop filter **96** may be determined to be shorter than a filter horizontal length thereof. For example, the loop filter **96** may be a polygonal shape having a filter vertical length and a filter horizontal length of 7 and 9, respectively.

[0154] In addition, when loop filtering is performed on pixels on upper and lower borders of the loop filtering area **92** in the current coding unit **91**, every three external pixels are referred to in a vertical direction to a border of the loop filtering area **92** along a filter vertical length of the loop filter **96**.

[0155] In this case, three external pixels outside an upper border of the current coding unit **91** may be a portion of lower pixels of a neighboring coding unit B which are necessary for deblocking filtering of the current coding unit **91**. The number of external pixels that are necessary for deblocking filtering of the upper border of the current coding unit **91** may be determined based on a filter vertical length of a deblocking filter.

[0156] In regard to a decoding period for the current coding unit **91**, the neighboring coding unit B is an already decoded data unit, and the lower pixels of the neighboring coding unit B that are necessary for deblocking filtering on the upper border of the current coding unit **91** are already imported and stored in a predetermined data storage space, and thus data may be easily accessible when performing loop filtering.

[0157] If every three external pixels are stored from the upper border of the current coding unit **91** for deblocking filtering, in a data storage space which is easily accessible when performing loop filtering, since all of upper border external pixels needed for loop filtering of the current coding unit **91** are easily accessible, the loop filtering area **92** may be extended and determined such that loop filtering may be performed up to internal pixels that are adjacent to the upper border of the current coding unit **91**.

[0158] However, in regard to loop filtering of a lower border of the current coding unit **91**, since external data on a lower border of the current coding unit **91** is not yet decoded due to the decoding sequence, external pixels outside the lower border of the current coding unit **91** may not be used. In addition, a pixel group **92** including some pixels on the lower border of the current coding unit **91** is data which is to be modified by prospective deblocking filtering.

[0159] Accordingly, the pixel group **95** whose data is to be modified by prospective deblocking filtering may be excluded from the loop filtering area **92**. Also, the loop filtering area **92** may be determined such that the pixel group **95** whose data is to be modified through prospective deblocking filtering is not referred to as neighbor pixels of loop filtering. A pixel group **94** to which loop filtering is performed may be determined by using the pixel group **95** whose data is to be modified by deblocking filtering, based on a filter vertical length of the loop filter **96**, and such that the pixel group **94** is also excluded from the loop filtering area **92** together with the pixel group **95**.

[0160] In detail, the loop filtering area **92** of the current coding unit **91** will be determined below as an example below when three external, neighbor pixels are used for deblocking filtering on a border pixel of the current coding unit **91**, and a filter vertical length of the loop filter **96** is 7.

[0161] The loop filtering area **92** of the current coding unit **91** may include up to an internal area adjacent to the upper border of the current coding unit **91** through deblocking filtering of the current coding unit **91**. Also, the lower border of the loop filtering area **92** may be reduced by every three pixels from the lower border of the current coding unit **91** to the inside thereof in consideration of the pixel group **95** whose data is to be modified by prospective deblocking filtering.

[0162] Also, by using the pixel group **95** whose data is to be modified by prospective deblocking filtering as neighbor pixels, and in consideration of the pixel group **94** on which loop filtering is to be performed, the lower border of the loop filtering area **92** may be additionally reduced by every three pixels which correspond to a half of a filter vertical length of a loop filter. Consequently, loop filtering is not performed on an area **93** including six pixels in a vertical direction from pixels on the lower border of the current coding unit **91**, and the remaining area except the area **93** adjacent to the lower border of the current coding unit **91** may be determined as the loop filtering area **92**.

[0163] For loop filtering regarding coding units A, B, C, D, and X of a current frame **100**, loop filtering according to an embodiment may not be performed on an area **110** in which six pixels are included from lower border pixels of each of coding unit in a vertical direction, thereby minimizing an operation delay which may additionally occur due to importation of data by neighboring pixels for loop filtering.

[0164] Also, as loop filtering may be performed by referring to data which is easily accessible for deblocking filtering from among external pixels outside the upper border of each coding unit, as much as possible, encoding error due to the loop filtering may be further reduced.

[0165] FIG. **11** is a flowchart illustrating a video encoding method using loop filtering according to an exemplary embodiment.

[0166] According to the video encoding method using loop filtering, loop filtering is performed while performing a basic video encoding operation in connection with a video encoding processor.

[0167] In operation **111** video data is encoded based on coding units which are obtained by splitting video data to spatial domains.

[0168] In operation **112**, loop filtering may be performed on a coding unit based on a minimum distance between a pixel on which loop filtering is to be performed, from among video data of a coding unit and a filter vertical length of a loop filter. At least one of a loop filtering area and a loop filter may be determined such that loop filtering on a coding unit is performed using internal pixels of the coding unit. Data of a spatial domain on which loop filtering is performed may be encoded again by motion estimation, transformation, and quantization.

[0169] A loop filtering area may be determined in an internal area away from at least one border of a coding unit a predetermined distance, based on a minimum distance between a pixel in a coding unit and a border of the coding unit and a filter length. A loop filtering area may be determined in an internal area that is away from at least one border of a coding unit at least a filter vertical length.

[0170] A loop filter may be determined such that a filter length of the loop filter is equal to or smaller than a minimum distance between a pixel in a coding unit and a border of a coding unit.

[0171] For example, at least one of a loop filtering area and a loop filter may be determined based on a minimum vertical distance with respect to borders of a coding unit and a filter vertical length of a loop filter. In addition, a loop filtering method may be determined based on a minimum horizontal distance with respect to borders of a coding unit and a filter horizontal length of a loop filter. A filter vertical length may be determined to be shorter than a filter horizontal length.

[0172] Also, a loop filtering area may be determined based on a minimum distance between a pixel in a coding unit and a border of a coding unit, and a filter length of a loop filter may be determined based on a minimum distance between a pixel of the determined loop filtering area and a border of a coding unit.

[0173] In addition, a loop filtering area may be determined based on a distance between a pixel in a coding unit and a border of the coding unit and a filter length of a loop filter, and within an internal area away from at least one border of a coding unit the previously determined filter length.

[0174] A loop filtering area may be determined based on a minimum distance between a pixel of a coding unit and a border of the coding unit, a filter length, and a height of a deblocking filtering area of the coding unit. A filter length of a loop filter may be determined based on a minimum distance between a pixel of a coding unit and a border of the coding unit, a filter length, and a height of a deblocking filtering area of the coding unit.

[0175] Within an internal area of a coding unit, a loop filtering area may be determined in the remaining area except an area whose data is to be modified by prospective deblocking filtering, that is, a deblocking filtering area.

[0176] At least one of a loop filtering area and a filter vertical length of a loop filter may be extended based on the number of pixels used in deblocking filtering for a coding unit, that is, a vertical length of deblocking filtering, from among external pixels on an upper border of a coding unit.

[0177] At least two loop filters may be determined for each coding unit or each frame. For example, for loop filtering of a current coding unit, at least two loop filters may be determined. In this case, the determined at least two loop filters may be determined to be different in terms of at least one of a loop filter type and a filter length.

[0178] In operation **113**, encoding information related to an encoding method based on a coding unit and encoded video data are output for each coding unit. The encoding information may include information indicating loop filtering performed for each coding unit, whether loop filtering is allowed, determination of a loop filtering method, and coefficients of a loop filter. A bit stream including encoding information indicating an encoding mode for decoding encoded video data and video data encoded for each coding unit may be output.

[0179] FIG. **12** is a flowchart illustrating a video decoding method by using loop filtering according to an exemplary embodiment.

[0180] In operation **121**, a bit stream of a video may be received and parsed to thereby extract encoding information and encoded video data.

[0181] In operation **122**, video data encoded for each coding unit may be decoded to data of a spatial domain through variable length decoding, inverse quantization, and inverse transformation, by using the encoding information extracted in operation **121**. According to the video decoding method by using loop filtering, basic video decoding operations for each coding unit may be performed in connection with a video decoding processor.

[0182] A loop filtering method may be determined based on a minimum distance between a pixel on which loop filtering is to be performed within a coding unit and a border of a coding unit, and a filter length of a loop filter, such that loop filtering may be performed by using internal pixel values of the coding unit.

[0183] A loop filtering area may be determined within an internal area that is away from at least one border of a coding unit at least a filter vertical length, based on a minimum distance between a pixel in a coding unit and a border of a coding unit.

[0184] A filter length of a loop filter may be determined to be smaller than or equal to a minimum distance between a pixel in a coding unit and a border of a coding unit.

[0185] For example, based on a minimum vertical distance with respect to borders of a coding unit and a filter vertical length of a loop filter, at least one of a loop filtering area and a loop filter may be determined. In addition, based on a horizontal minimum distance with respect to borders of a coding unit and a filter horizontal length of a loop filter, at least one of a loop filtering area and a loop filter may be determined. A filter vertical length may be determined to be shorter than a filter horizontal length.

[0186] Also, a loop filtering area may be determined based on a minimum distance between a pixel in a coding unit and a border of a coding unit, and a filter length of a loop filter may be determined based on a minimum distance between a pixel of the determined loop filtering area and a border of a coding unit. Also, a loop filtering area may be determined based on a distance between a pixel in a coding unit and a border of a coding unit and a filter length of a loop filter, and within an internal area away from at least one border of a coding unit in a coding unit the above-described filter length.

[0187] Based on a minimum distance between a pixel of a coding unit and a border of a coding unit and a height of a deblocking filtering area of a coding unit, at least one of a loop filtering area and a filter length of a loop filter may be determined.

[0188] For example, a loop filtering area may be determined in the remaining area except an area in which data is modified by prospective deblocking filtering in an internal area of a coding unit.

[0189] From among external pixels of an upper border of a coding unit, based on the number of pixels used for deblocking filtering for a coding unit, that is, a vertical length of a deblocking filter, at least one of a loop filtering area and a filter vertical length of a loop filter may be extended.

[0190] For each coding unit or each frame, at least two loop filters which are different in terms of at least one of a filter type and a filter length may be determined.

[0191] In operation **123**, with respect to video data that is decoded in operation **122**, loop filtering with respect to a coding unit may be performed by using internal pixels of a coding unit. For each coding unit, decoded video data and data to which loop filtering is performed may be combined to restore a video. In operation **124**, video may be restored for each coding unit and the restored video may be output.

[0192] Hereinafter, a method of determining coding units having a tree structure according to an exemplary embodiment will be described in the case when the video encoding apparatus **10** performs loop filtering based on coding units of a tree structure.

[0193] The ALF coding unit **11** may split a current picture based on a maximum coding unit for the current picture of an image. If the current picture is larger than the maximum coding unit, image data of the current picture may be split into at least one maximum coding unit. The maximum coding unit may be a data unit having a size of 32×32, 64×64, 128×128, 256×256, etc., wherein a shape of the data unit is a square having a width and length in squares of 2. The image data may be output to the ALF coding unit **11** according to the at least one maximum coding unit.

[0194] A coding unit may be characterized by a maximum size and a depth. The depth denotes a number of times the coding unit is spatially split from the maximum coding unit, and as the depth deepens, deeper coding units according to depths may be split from the maximum coding unit to a minimum coding unit. A depth of the maximum coding unit is an uppermost depth and a depth of the minimum coding unit is a lowermost depth. Since a size of a coding unit corresponding to each depth decreases as the depth of the maximum coding unit deepens, a coding unit corresponding to an upper depth may include a plurality of coding units corresponding to lower depths.

[0195] As described above, the image data of the current picture is split into the maximum coding units according to a maximum size of the coding unit, and each of the maximum coding units may include deeper coding units that are split according to depths. Since the maximum coding unit is split according to depths, the image data of a spatial domain included in the maximum coding unit may be hierarchically classified according to depths.

[0196] A maximum depth and a maximum size of a coding unit, which limit the total number of times a height and a width of the maximum coding unit are hierarchically split may be predetermined.

[0197] The ALF coding unit **11** encodes at least one split region obtained by splitting a region of the maximum coding unit according to depths, and determines a depth to output a finally encoded image data according to the at least one split region. In other words, the ALF coding unit **11** may determine a coded depth by encoding the image data in the deeper coding units according to depths, according to the maximum coding unit of the current picture, and selecting a depth having the least encoding error. The determined coded depth and the encoded image data according to the maximum coding units are output to the output unit **12**.

[0198] The image data in the maximum coding unit is encoded based on the deeper coding units corresponding to at least one depth equal to or below the maximum depth, and results of encoding the image data are compared based on each of the deeper coding units. A depth having the least encoding error may be selected after comparing encoding errors of the deeper coding units. At least one coded depth may be selected for each maximum coding unit.

[0199] The size of the maximum coding unit is split as a coding unit is hierarchically split according to depths, and as the number of coding units increases. Also, even if coding units corresponding to same depth in one maximum coding unit, each of the coding units corresponding to the same depth may be split to a lower depth by measuring an encoding error of the image data of the each coding unit, separately. Accordingly, even when image data is included in one maximum coding unit, the encoding errors may differ according to regions in the one maximum coding unit, and thus the coded depths may differ according to regions in the image data. Thus, one or more coded depths may be determined in one maximum coding unit, and the image data of the maximum coding unit may be divided according to coding units of at least one coded depth.

[0200] Accordingly, the ALF coding unit **11** may determine coding units having a tree structure included in the maximum coding unit. The 'coding units having a tree structure' include coding units corresponding to a depth determined to be the coded depth, from among all deeper coding units included in the maximum coding unit. A coding unit of a coded depth may be hierarchically determined according to depths in the same region of the maximum coding unit, and may be independently determined in different regions. Similarly, a coded depth in a current region may be independently determined from a coded depth in another region.

[0201] A maximum depth is an index related to the number of splitting times from a maximum coding unit to a minimum coding unit. A maximum depth may denote the total number of splitting times from the maximum coding unit to the minimum coding unit. For example, when a depth of the maximum coding unit is 0, a depth of a coding unit, in which the maximum coding unit is split once, may be set to 1, and a depth of a coding unit, in which the maximum coding unit is split twice, may be set to 2. Here, if the minimum coding unit is a coding unit in which the maximum coding unit is split four times, 5 depth levels of depths 0, 1, 2, 3 and 4 exist, and thus the maximum depth may be set to 4.

[0202] Prediction encoding and transformation may be performed according to the maximum coding unit. The prediction encoding and the transformation are also performed based on the deeper coding units according to a depth equal to or depths less than the maximum depth, according to the maximum coding unit. Transformation may be performed according to methods of frequency transformation, orthogonal transformation, or integer transformation.

[0203] Since the number of deeper coding units increases whenever the maximum coding unit is split according to depths, encoding including the prediction encoding and the transformation is performed on all of the deeper coding units generated as the depth deepens. For convenience of description, the prediction encoding and the transformation will now be described based on a coding unit of a current depth, in at least one maximum coding unit.

[0204] The video encoding apparatus **10** may variously select a size or shape of a data unit for encoding the image data. In order to encode the image data, operations, such as prediction encoding, transformation, and entropy encoding, are performed, and at this time, the same data unit may be used for all operations or different data units may be used for each operation.

[0205] For example, the video encoding apparatus **10** may select not only a coding unit for encoding the image data, but also a data unit different from the coding unit so as to perform the prediction encoding on the image data in the coding unit.

[0206] In order to perform prediction encoding in the maximum coding unit, the prediction encoding may be performed based on a coding unit corresponding to a coded depth, i.e., based on a coding unit that is no longer split to coding units corresponding to a lower depth. Hereinafter, the coding unit that is no longer split and becomes a basis unit for prediction encoding will now be referred to as a 'prediction unit'. A partition obtained by splitting the prediction unit may include a data unit obtained by splitting at least one of a height and a width of the prediction unit.

[0207] For example, when a coding unit of 2N×2N (where N is a positive integer) is no longer split, the coding unit becomes a prediction unit of 2N×2N, and a size of a partition may be 2N×2N, 2N×N, N×2N, or N×N. Examples of a partition type include symmetrical partitions that are obtained by symmetrically splitting a height or width of the prediction unit, partitions obtained by asymmetrically splitting the height or width of the prediction unit, such as 1:n or n:1, partitions that are obtained by geometrically splitting the prediction unit, and partitions having arbitrary shapes.

[0208] A prediction mode of the prediction unit may be at least one of an intra mode, an inter mode, and a skip mode. For example, the intra mode or the inter mode may be performed on the partition of 2N×2N, 2N×N, N×2N, or N×N. Also, the skip mode may be performed only on the partition of 2N×2N. The encoding is independently performed on one prediction unit in a coding unit, thereby selecting a prediction mode having a least encoding error.

[0209] The video encoding apparatus **10** may also perform the transformation on the image data in a coding unit based not only on the coding unit for encoding the image data, but also based on a data unit that is different from the coding unit.

[0210] In order to perform the transformation in the coding unit, the transformation may be performed based on a transformation unit having a size smaller than or equal to the coding unit. For example, the transformation unit may include a data unit for an intra mode and a data unit for an inter mode.

[0211] Similarly to the coding unit having a tree structure, the transformation unit in the coding unit may be recursively split into smaller sized regions, and thus, residual data in the coding unit may be divided according to transformation depth.

[0212] Also for a transformation unit, transformation depth denoting times of splitting a coding unit by splitting a height and a width of the coding unit to be a transformation may be set. For example, if a size of a transformation unit of a current coding unit having a size of 2N×2N is 2N×2N, a transformation depth may be set to 0, and if a size of a transformation unit is N×N, transformation depth may be set to 1, and if a size of a transformation unit is N/2×N/2, a transformation depth may be set to 2. That is, a transformation unit having a tree structure may also be set according to transformation depth.

[0213] Encoding information according to coding units corresponding to a coded depth requires not only information about the coded depth, but also information related to prediction and transformation. Accordingly, the ALF coding unit **11**

not only determines a coded depth having a lowest encoding error, but also a partition type in a prediction unit, a prediction mode according to prediction units, and a size of a transformation unit for transformation.

[0214] Coding units having a tree structure in a maximum coding unit and a method of determining a partition, according to exemplary embodiments, will be described in detail later with reference to FIGS. **13** through **23**.

[0215] The ALF coding unit **11** may measure an encoding error of deeper coding units according to depths by using Rate-Distortion Optimization based on Lagrangian multipliers.

[0216] The ALF coding unit **11** may perform loop filtering on video data of a spatial domain that is restored by performing inverse quantization, inverse transformation, and motion estimation with respect to a quantized transformation coefficient of a predetermined coding unit from among coding units having a tree structure.

[0217] The ALF coding unit **11** may output a transformation coefficient that is quantized by performing motion estimation, transformation, and quantization again to the video data that is filtered by loop filtering. Also, the quantized transformation coefficient may be output after being subject to variable length coding.

[0218] The ALF coding unit **11** may determine a loop filtering method based on a minimum distance between a pixel on which loop filtering is to be performed, from among internal pixels of a coding unit, and a border of a coding unit. A loop filtering method may also be determined based on a filter length of a loop filter. The method of determining a loop filtering method may be as described above with reference to FIGS. **1** through **12**.

[0219] The output unit **12** outputs the image data in the maximum coding unit, which is encoded based on the at least one coded depth determined by the ALF coding unit **11**, and information about the encoding mode according to the coded depth, in bit streams.

[0220] The encoded image data may be obtained by encoding residual data of an image.

[0221] The information about the encoding mode according to coded depth may include information about the coded depth, about the partition type in the prediction unit, the prediction mode, and the size of the transformation unit.

[0222] The information about the coded depth may be defined by using split information according to depths, which indicates whether encoding is performed on coding units of a lower depth instead of a current depth. If the current depth of the current coding unit is the coded depth, image data in the current coding unit is encoded in a coding unit according to the current depth, and thus the split information of the current depth may be defined not to split the current coding unit to a lower depth. Alternatively, if the current depth of the current coding unit is not the coded depth, encoding using the coding unit of the lower depth is to be tried, and thus the split information of the current depth may be defined to split the current coding unit to obtain the coding units of the lower depth.

[0223] If the current depth is not the coded depth, encoding is performed on the coding unit that is split into the coding unit of the lower depth. Since at least one coding unit of the lower depth exists in one coding unit of the current depth, the encoding is repeatedly performed on each coding unit of the lower depth, and thus the encoding may be recursively performed for the coding units having the same depth.

[0224] Since the coding units having a tree structure are determined for one maximum coding unit, and information about at least one encoding mode is determined for a coding unit of a coded depth, information about at least one encoding mode may be determined for one maximum coding unit. Also, a coded depth of the image data of the maximum coding unit may be different according to locations since the image data is hierarchically split according to depths, and thus information about the coded depth and the encoding mode may be set for the image data.

[0225] Accordingly, the output unit **12** may assign encoding information about a corresponding coded depth and an encoding mode to at least one of the coding unit, the prediction unit, and a minimum unit included in the maximum coding unit. The output unit **12** may insert the encoding information about a corresponding encoding depth and an encoding mode to a header of a bit stream, a sequence parameter set (SPS), or a picture parameter set (PPS) or the like for transmitting of coded video data, and output the same.

[0226] The minimum unit is a rectangular data unit obtained by splitting a minimum coding unit constituting the lowermost depth by 4. Alternatively, the minimum unit may be a maximum rectangular data unit that may be included in all of the coding units, prediction units, partition units, and transformation units included in the maximum coding unit.

[0227] For example, the encoding information output through the output unit **12** may be classified into encoding information according to deeper coding units, and encoding information according to prediction units. The encoding information according to the deeper coding units may include the information about the prediction mode and about the size of the partitions. The encoding information transmitted according to the prediction units may include information about an estimated direction of an inter mode, about a reference image index of the inter mode, about a motion vector, about a chroma component of an intra mode, and about an interpolation method of the intra mode.

[0228] Also, structure information for determining coding units having a tree structure such as information about a maximum size of the coding unit defined according to pictures, slices, or group of pictures (GOPs), and information about a variable range of the depth may be inserted into a header of a bit stream, a SPS, a PPS or the like.

[0229] Also, the encoding information output through the output unit **12** may include transformation indices. Transformation index information may denote information about a structure of a transformation unit used in transforming a current coding unit. For example, transformation index information may include information about the number of times of splitting a current coding unit to a final-level transformation unit and a size and shape of a transformation unit.

[0230] Transformation index information may indicate whether a current transformation unit is split into a transformation unit of a lower level. For example, as transformation index information, a transformation unit split bit which is data of a bit indicating whether a transformation unit is split into a transformation unit of a lower level may be used.

[0231] Also, coding unit output through the output unit **12** may transmit filter coefficients for loop filtering as encoding information. Also, the output unit **12** may transmit encoding information about a loop filtering method for signaling whether loop filtering is allowed, whether modification of a loop filtering area is allowed, whether modification of a loop filter is allowed, whether modification of the loop filtering method is allowed, or whether loop filtering may be overlapped with deblocking filtering.

[0232] In the video encoding apparatus **10** according to an exemplary embodiment, the deeper coding unit may be a coding unit obtained by splitting a height or width of a coding unit of an upper depth, which is one layer above, by two. In other words, when the size of the coding unit of the current depth is 2N×2N, the size of the coding unit of the lower depth is N×N. Also, the coding unit of the current depth having the size of 2N×2N may include maximum 4 of the coding units of the lower depth.

[0233] Accordingly, the video encoding apparatus **10** may form the coding units having the tree structure by determining coding units having an optimum shape and an optimum size for each maximum coding unit, based on the size of the maximum coding unit and the maximum depth determined considering characteristics of the current picture. Also, since encoding may be performed on each maximum coding unit by using any one of various prediction modes and transformations, an optimum encoding mode may be determined considering characteristics of the coding unit of various image sizes.

[0234] Thus, if an image having a high resolution or a large data amount is encoded in conventional macroblock units, a number of macroblocks per picture excessively increases. Accordingly, a number of pieces of compressed information generated for each macroblock increases, and thus it is difficult to transmit the compressed information and data compression efficiency decreases. However, by using the video encoding apparatus **10**, image compression efficiency may be increased since a coding unit is adjusted in consideration of characteristics of an image while increasing a maximum size of a coding unit while considering a size of the image.

[0235] Hereinafter, a method of decoding a video based on coding units having a tree structure according to an exemplary embodiment to perform loop filtering based on coding units having a tree structure according to an exemplary embodiment will be described.

[0236] The definitions of terms such as coding unit, depth, prediction unit, transformation unit, and various encoding modes for various processings of the video decoding apparatus **20** are the same as those described with reference to the video encoding apparatus **10**.

[0237] The receiving unit **21** may receive a bit stream of an encoded video and parse the same. The receiving unit **21** may extract image data encoded for each coding unit according to coding units having a tree structure for each maximum coding unit from the parsed bit stream to output the same to the ALF decoding unit **22**. The receiving unit **21** may parse and extract structure information for determining coding units having a tree structure such as information about a maximum size of a coding unit of a current picture and a variable length of depth or the like, from at least one of a header, SPS, and PPS regarding a current picture from the received bit stream.

[0238] Also, the receiving unit **21** may extract encoding depth of coding units having a tree structure for each maximum coding unit and information about an encoding mode from the parsed bit stream. The extracted information about encoding depth and encoding modes is output to the ALF decoding unit **22**. That is, image data of a bit rate is split to maximum coding units so that the ALF decoding unit **22** may decode image data for each maximum coding unit.

[0239] The information about encoding depth and encoding modes for each maximum coding unit may be set for at least one piece of encoding depth information, and information about encoding modes for each encoding depth may include partition type information of a corresponding coding unit, prediction mode information, and size information of a transformation unit. Also, as encoding depth information, split information according to depths may also be extracted.

[0240] Also, from the encoding mode information that is extracted from the parsed bit stream by using the ALF decoding unit **22**, information about transformation indices may be read. The ALF decoding unit **22** may configure a transformation unit of a current coding unit based on the transformation index information extracted by the receiving unit **21**, and decode encoded data by performing inverse transformation of a current coding unit based on the transformation unit.

[0241] Also, encoding information extracted by using the receiving unit **21** may include filter coefficients for loop filtering. Also, the receiving unit **21** may extract encoding information about loop filtering, from the bit stream, and information regarding whether loop filtering is allowed, whether modification of a loop filtering area is allowed, whether modification of a loop filter is allowed, whether modification of the loop filtering method is allowed, or whether loop filtering may be overlapped with deblocking filtering may also be read from the encoding mode information.

[0242] After the ALF decoding unit **22** has decoded video data of a spatial domain based on coding units, the decoding unit **230** may restore pictures of a video.

[0243] The information about the coded depth and the encoding mode according to each maximum coding unit extracted by using the receiving unit **21** is information about a coded depth and an encoding mode determined to generate a minimum encoding error when an encoder such as the video encoding apparatus **10** repeatedly performs encoding for each deeper coding unit according to depths according to each maximum coding unit. Accordingly, the video decoding apparatus **20** may restore an image by decoding the image data according to an encoding method that generates the minimum encoding error.

[0244] Since encoding information about the coded depth and the encoding mode may be assigned to a predetermined data unit from among a corresponding coding unit, a prediction unit, and a minimum unit, the receiving unit **21** may extract the information about the coded depth and the encoding mode according to the predetermined data units. The predetermined data units to which the same information about the coded depth and the encoding mode is assigned may be inferred to be the data units included in the same maximum coding unit if the information about the coded depth and the encoding mode of a corresponding maximum encoding unit is recorded for each predetermined data unit.

[0245] The ALF decoding unit **22** restores the current picture by decoding the image data in each maximum coding unit based on the information about the coded depth and the encoding mode according to the maximum coding units. In other words, the ALF decoding unit **22** may decode the encoded image data based on the extracted information about the partition type, the prediction mode, and the transformation unit for each coding unit from among the coding units having the tree structure included in each maximum coding unit. A decoding process may include a prediction including intra prediction and motion compensation, and an inverse transformation.

[0246] The ALF decoding unit **22** may perform intra prediction or motion compensation according to a partition and a prediction mode of each coding unit, based on the information about the partition type and the prediction mode of the prediction unit of the coding unit according to coded depths.

[0247] Also, the ALF decoding unit **22** may perform inverse transformation according to each transformation unit in the coding unit, based on the information about the size of the transformation unit of the coding unit according to coded depths, so as to perform the inverse transformation according to maximum coding units.

[0248] The ALF decoding unit **22** may determine at least one coded depth of a current maximum coding unit by using split information according to depths. If the split information indicates that image data is no longer split in the current depth, the current depth is a coded depth. Accordingly, the ALF decoding unit **22** may decode encoded image data of a coding unit corresponding to the current coded depth in the current maximum coding unit by using the information about the partition type of the prediction unit, the prediction mode, and the size of the transformation unit for each coding unit corresponding to the coded depth, and output the image data of the current maximum coding unit.

[0249] In other words, data units containing the encoding information including the same split information may be gathered by observing the encoding information set assigned for the predetermined data unit from among the coding unit, the prediction unit, and the minimum unit, and the gathered data units may be considered to be one data unit to be decoded by the ALF decoding unit **22** in the same encoding mode.

[0250] The ALF decoding unit **22** may perform loop filtering on the restored video data of a spatial domain that is restored by performing variable length decoding, inverse quantization, inverse transformation, and motion compensation on coding units having a tree structure.

[0251] The ALF decoding unit **22** may determine a loop filtering method based on a minimum distance between a pixel on which loop filtering is to be performed, from among internal pixels of a coding unit, and a border of the coding unit. A loop filtering method may also be determined based on a filter length of a loop filter. The method of determining a loop filtering method may be as described above with reference to FIGS. **1** through **12**.

[0252] The video decoding apparatus **20** may obtain information about a coding unit that generates the minimum encoding error when encoding is recursively performed for each maximum coding unit, and may use the information to decode the current picture. In other words, encoded image data of coding units having a tree structure determined to be the optimum coding units in each maximum coding unit may be decoded.

[0253] Accordingly, even if image data has a high resolution and an excessively large amount of data, the image data may be efficiently decoded and restored according to a size of a coding unit and an encoding mode, which are adaptively determined according to characteristics of the image data, by using information about an optimum encoding mode received from an encoder.

[0254] A method for encoding and decoding a video based on a data unit such as a coding unit having a tree structure according to an exemplary embodiment will now be described with reference to FIGS. **13** through **23**.

[0255] FIG. **13** is a diagram for describing a concept of coding units according to an exemplary embodiment.

[0256] A size of a coding unit may be expressed in width×height, and may be 64×64, 32×32, 16×16, and 8×8. A coding unit of 64×64 may be split into partitions of 64×64, 64×32, 32×64, or 32×32, and a coding unit of 32×32 may be split into partitions of 32×32, 32×16, 16×32, or 16×16, a coding unit of 16×16 may be split into partitions of 16×16, 16×8, 8×16, or 8×8, and a coding unit of 8×8 may be split into partitions of 8×8, 8×4, 4×8, or 4×4.

[0257] In video data **310**, a resolution is 1920×1080, a maximum size of a coding unit is 64, and a maximum depth is 2. In video data **320**, a resolution is 1920×1080, a maximum size of a coding unit is 64, and a maximum depth is 3. In video data **330**, a resolution is 352×288, a maximum size of a coding unit is 16, and a maximum depth is 1. The maximum depth shown in FIG. **13** denotes a total number of splits from a maximum coding unit to a minimum decoding unit.

[0258] If a resolution is high or a data amount is large, a maximum size of a coding unit may be large so as to not only increase encoding efficiency but also to accurately reflect characteristics of an image. Accordingly, the maximum size of the coding unit of the video data **310** and **320** having the higher resolution than the video data **330** may be 64.

[0259] Since the maximum depth of the video data **310** is 2, coding units **315** of the vide data **310** may include a maximum coding unit having a long axis size of 64, and coding units having long axis sizes of 32 and 16 since depths are deepened to two layers by splitting the maximum coding unit twice. Meanwhile, since the maximum depth of the video data **330** is 1, coding units **335** of the video data **330** may include a maximum coding unit having a long axis size of 16, and coding units having a long axis size of 8 since depths are deepened to one layer by splitting the maximum coding unit once.

[0260] Since the maximum depth of the video data **320** is 3, coding units **325** of the video data **320** may include a maximum coding unit having a long axis size of 64, and coding units having long axis sizes of 32, 16, and 8 since the depths are deepened to 3 layers by splitting the maximum coding unit three times. As a depth deepens, detailed information may be precisely expressed.

[0261] FIG. **14** is a block diagram of an image encoder **400** based on coding units, according to an exemplary embodiment.

[0262] The image encoder **400** performs operations of the ALF coding unit **11** of the video encoding apparatus **10** to encode image data. In other words, an intra predictor **410** performs intra prediction on coding units in an intra mode, from among a current frame **405**, and a motion estimator **420** and a motion compensator **425** performs inter estimation and motion compensation on coding units in an inter mode from among the current frame **405** by using the current frame **405**, and a reference frame **495**.

[0263] Data output from the intra predictor **410**, the motion estimator **420**, and the motion compensator **425** is output as a quantized transformation coefficient through a transformer **430** and a quantizer **440**. The quantized transformation coefficient is restored as data in a spatial domain through an inverse quantizer **460** and an inverse transformer **470**, and the restored data in the spatial domain is output as the reference frame **495** after being post-processed through a deblocking unit **480** and a loop filtering unit **490**. The quantized transformation coefficient may be output as a bit stream **455** through an entropy encoder **450**.

[0264] In order for the image encoder **400** to be applied in the video encoding apparatus **10**, all elements of the image encoder **400**, i.e., the intra predictor **410**, the motion estimator

420, the motion compensator **425**, the frequency transformer **430**, the quantizer **440**, the entropy encoder **450**, the inverse quantizer **460**, the inverse transformer **470**, the deblocking unit **480**, and the loop filtering unit **490** perform operations based on each coding unit from among coding units having a tree structure while considering the maximum depth of each maximum coding unit.

[0265] Specifically, the intra predictor **410**, the motion estimator **420**, and the motion compensator **425** determine partitions and a prediction mode of each coding unit from among the coding units having a tree structure while considering the maximum size and the maximum depth of a current maximum coding unit, and the frequency transformer **430** determines the size of the transformation unit in each coding unit from among the coding units having a tree structure.

[0266] FIG. **15** is a block diagram of an image decoder **500** based on coding units, according to an exemplary embodiment.

[0267] A parser **510** parses encoded image data to be decoded and information about encoding required for decoding from a bit stream **505**. The encoded image data is output as inverse quantized data through an entropy decoder **520** and an inverse quantizer **530**, and the inverse quantized data is restored to image data in a spatial domain through an inverse transformer **540**.

[0268] An intra predictor **550** performs intra prediction on coding units in an intra mode with respect to the image data in the spatial domain, and a motion compensator **560** performs motion compensation on coding units in an inter mode by using a reference frame **585**.

[0269] The image data in the spatial domain, which passed through the intra predictor **550** and the motion compensator **560**, may be output as a restored frame **595** after being post-processed through a deblocking unit **570** and a loop filtering unit **580**. Also, the image data that is post-processed through the deblocking unit **570** and the loop filtering unit **580** may be output as the reference frame **585**.

[0270] In order to decode the image data in the ALF decoding unit **22** of the video decoding apparatus **20**, the image decoder **500** may perform operations that are performed after the parser **510**.

[0271] In order for the image decoder **500** to be applied in the video decoding apparatus **20**, all elements of the image decoder **500**, i.e., the parser **510**, the entropy decoder **520**, the inverse quantizer **530**, the inverse frequency transformer **540**, the intra predictor **550**, the motion compensator **560**, the deblocking unit **570**, and the loop filtering unit **580** perform operations based on coding units having a tree structure for each maximum coding unit.

[0272] Specifically, the intra prediction **550** and the motion compensator **560** perform operations based on partitions and a prediction mode for each of the coding units having a tree structure, and the inverse frequency transformer **540** perform operations based on a size of a transformation unit for each coding unit.

[0273] FIG. **16** is a diagram illustrating deeper coding units according to depths, and partitions, according to an exemplary embodiment.

[0274] The video encoding apparatus **10** and the video decoding apparatus **20** use hierarchical coding units so as to consider characteristics of an image. A maximum height, a maximum width, and a maximum depth of coding units may be adaptively determined according to the characteristics of the image, or may be differently set by a user. Sizes of deeper coding units according to depths may be determined according to the predetermined maximum size of the coding unit.

[0275] In a hierarchical structure **600** of coding units, according to an embodiment, the maximum height and the maximum width of the coding units are each 64, and the maximum depth is 3. The maximum depth denotes the total number of splitting times from the maximum coding unit to the minimum coding unit. Since a depth deepens along a vertical axis of the hierarchical structure **600**, a height and a width of the deeper coding unit are each split. Also, a prediction unit and partitions, which are bases for prediction encoding of each deeper coding unit, are shown along a horizontal axis of the hierarchical structure **600**.

[0276] In other words, a coding unit **610** is a maximum coding unit in the hierarchical structure **600**, wherein a depth is 0 and a size, i.e., a height by width, is 64×64. The depth deepens along the vertical axis, and a coding unit **620** having a size of 32×32 and a depth of 1, a coding unit **630** having a size of 16×16 and a depth of 2, and a coding unit **640** having a size of 8×8 and a depth of 3 exist. The coding unit **640** having the size of 8×8 and the depth of 3 is a minimum coding unit.

[0277] The prediction unit and the partitions of a coding unit are arranged along the horizontal axis according to each depth. In other words, if the coding unit **610** having the size of 64×64 and the depth of 0 is a prediction unit, the prediction unit may be split into partitions included in the coding unit **610**, i.e. a partition **610** having a size of 64×64, partitions **612** having the size of 64×32, partitions **614** having the size of 32×64, or partitions **616** having the size of 32×32.

[0278] Similarly, a prediction unit of the coding unit **620** having the size of 32×32 and the depth of 1 may be split into partitions included in the coding unit **620**, i.e. a partition **620** having a size of 32×32, partitions **622** having a size of 32×16, partitions **624** having a size of 16×32, and partitions **626** having a size of 16×16.

[0279] Similarly, a prediction unit of the coding unit **630** having the size of 16×16 and the depth of 2 may be split into partitions included in the coding unit **630**, i.e. a partition having a size of 16×16 included in the coding unit **630**, partitions **632** having a size of 16×8, partitions **634** having a size of 8×16, and partitions **636** having a size of 8×8.

[0280] Similarly, a prediction unit of the coding unit **640** having the size of 8×8 and the depth of 3 may be split into partitions included in the coding unit **640**, i.e. a partition having a size of 8×8 included in the coding unit **640**, partitions **642** having a size of 8×4, partitions **644** having a size of 4×8, and partitions **646** having a size of 4×4.

[0281] In order to determine a coded depth of the coding units constituting the maximum coding unit **610**, the ALF coding unit **11** of the video encoding apparatus **10** performs encoding for coding units corresponding to each depth included in the maximum coding unit **610**.

[0282] A number of deeper coding units according to depths including data in the same range and the same size increases as the depth deepens. For example, four coding units corresponding to a depth of 2 are required to cover data that is included in one coding unit corresponding to a depth of 1. Accordingly, in order to compare encoding results of the same data according to depths, the coding unit corresponding to the depth of 1 and four coding units corresponding to the depth of 2 are each encoded.

[0283] In order to perform encoding for each depth, a representative encoding error, which is a least encoding error for a current depth, may be selected by performing encoding for each prediction unit in the coding units corresponding to the current depth, along the horizontal axis of the hierarchical structure **600**. Alternatively, the minimum encoding error may be searched for by comparing the least encoding errors according to depths, by performing encoding for each depth as the depth deepens along the vertical axis of the hierarchical structure **600**. A depth and a partition having the minimum encoding error in the coding unit **610** may be selected as the coded depth and a partition type of the coding unit **610**.

[0284] FIG. **17** is a diagram for describing a relationship between a coding unit **710** and a transformation unit **720**, according to an exemplary embodiment.

[0285] The video encoding apparatus **10** or the video decoding apparatus **20** may encode or decode an image according to coding units having sizes smaller than or equal to a maximum coding unit for each maximum coding unit. Sizes of transformation units for transformation during encoding may be selected based on data units that are not larger than each coding unit.

[0286] For example, in the video encoding apparatus **10** or the video decoding apparatus **20**, if a size of the coding unit **710** is 64×64, transformation may be performed by using the transformation unit **720** having a size of 32×32.

[0287] Also, data of the coding unit **710** having the size of 64×64 may be encoded by performing the transformation on each of the transformation units having the size of 32×32, 16×16, 8×8, and 4×4, which are smaller than 64×64, and then a transformation unit having the least coding error may be selected.

[0288] FIG. **18** is a diagram for describing encoding information of coding units corresponding to a coded depth, according to an exemplary embodiment.

[0289] The output unit **12** of the video encoding apparatus **10** may encode and transmit information **800** about a partition type, information **810** about a prediction mode, and information **820** about a size of a transformation unit for each coding unit corresponding to a coded depth, as information about an encoding mode.

[0290] The information **800** indicates information about a shape of a partition obtained by splitting a prediction unit of a current coding unit, wherein the partition is a data unit for prediction encoding the current coding unit. For example, a current coding unit CU__0 having a size of 2N×2N may be split into any one of a partition **802** having a size of 2N×2N, a partition **804** having a size of 2N×N, a partition **806** having a size of N×2N, and a partition **808** having a size of N×N. Here, the information **800** about a partition type is set to indicate one of the partition **804** having a size of 2N×N, the partition **806** having a size of N×2N, and the partition **808** having a size of N×N

[0291] The information **810** indicates a prediction mode of each partition. For example, the information **810** may indicate a mode of prediction encoding performed on a partition indicated by the information **800**, i.e., an intra mode **812**, an inter mode **814**, or a skip mode **816**.

[0292] The information **820** indicates a transformation unit to be based on when transformation is performed on a current coding unit. For example, the transformation unit may be a first intra transformation unit **822**, a second intra transformation unit **824**, a first inter transformation unit **826**, or a second inter transformation unit **828**.

[0293] The receiving unit **21** of the video decoding apparatus **20** may extract and use the information **800**, **810**, and **820** for decoding.

[0294] FIG. **19** is a diagram of deeper coding units according to depths, according to an exemplary embodiment.

[0295] Split information may be used to indicate a change of a depth. The spilt information indicates whether a coding unit of a current depth is split into coding units of a lower depth.

[0296] A prediction unit **910** for prediction encoding a coding unit **900** having a depth of 0 and a size of 2N__0×2N__0 may include partitions of a partition type **912** having a size of 2N__0×2N__0, a partition type **914** having a size of 2N__0×N__0, a partition type **916** having a size of N__0×2N__0, and a partition type **918** having a size of N__0×N__0. FIG. **9** only illustrates the partition types **912**, **914**, **916**, and **918** obtained by symmetrically splitting the prediction unit **910**, but a partition type is not limited thereto, and the partitions of the prediction unit **910** may include asymmetrical partitions, partitions having a predetermined shape, and partitions having a geometrical shape.

[0297] Prediction encoding is repeatedly performed on one partition having a size of 2N__0×2N__0, two partitions having a size of 2N__0×N__0, two partitions having a size of N__0×2N__0, and four partitions having a size of N__0×N__0, according to each partition type. The prediction encoding in an intra mode and an inter mode may be performed on the partitions having the sizes of 2N__0×2N__0, N__0×2N__0, 2N__0×N__0, and N__0×N__0. The prediction encoding in a skip mode is performed only on the partition having the size of 2N__0×2N__0.

[0298] If an encoding error is smallest in one of the partition types **912**, **914**, and **916**, the prediction unit **910** may not be split into a lower depth.

[0299] If the encoding error is the smallest in the partition type **918** having a size of N__0×N__0, a depth is changed from 0 to 1 to split the partition type **918** in operation **920**, and encoding is repeatedly performed on coding units **930** having a depth of 2 and a size of N__0×N__0 to search for a minimum encoding error.

[0300] A prediction unit **940** for prediction encoding the coding unit **930** having a depth of 1 and a size of 2N__1×2N__1 (=N__0×N__0) may include partitions of a partition type **942** having a size of 2N__1×2N__1 a partition type **944** having a size of 2N__1×N__1, a partition type **946** having a size of N__1×2N__1, and a partition type **948** having a size of N__1×N__1.

[0301] If an encoding error is the smallest in the partition type **948**, a depth is changed from 1 to 2 to split the partition type **948** in operation **950**, and encoding is repeatedly performed on coding units **960**, which have a depth of 2 and a size of N__2×N__2 to search for a minimum encoding error.

[0302] When a maximum depth is d-1, split operation according to each depth may be performed up to when a depth becomes d-1, and split information may be encoded as up to when a depth is one of 0 to d-2. In other words, when encoding is performed up to when the depth is d-1 after a coding unit corresponding to a depth of d-2 is split in operation **970**, a prediction unit **990** for prediction encoding a coding unit **980** having a depth of d-1 and a size of 2N_(d-1)×2N_(d-1) may include partitions of a partition type **992** having a size of 2N_(d-1)×2N_(d-1), a partition type **994** having a size of

2N_(d-1)×N_(d-1), a partition type **996** having a size of N_(d-1)×2N_(d-1), and a partition type **998** having a size of N_(d-1)×N_(d-1).

[0303] Prediction encoding may be repeatedly performed on one partition having a size of 2N_(d-1)×2N_(d-1), two partitions having a size of 2N_(d-1)×N_(d-1), two partitions having a size of N_(d-1)×2N_(d-1), four partitions having a size of N_(d-1)×N_(d-1) from among the partition types **992** through **998** to search for a partition type having a minimum encoding error.

[0304] Even when the partition type **998** has the minimum encoding error, since a maximum depth is d-1, a coding unit CU_(d-1) having a depth of d-1 is no longer split to a lower depth, and a coded depth for the coding units constituting a current maximum coding unit **900** is determined to be d-1 and a partition type of the coding unit **900** may be determined to be N_(d-1)×N_(d-1). Also, since the maximum depth is d-1, split information for a coding unit **980** of the depth d-1 is not set.

[0305] A data unit **999** may be a 'minimum unit' for the current maximum coding unit. A minimum unit according to an embodiment may be a rectangular data unit obtained by splitting a minimum coding unit by 4. By performing the encoding repeatedly, the video encoding apparatus **10** may select a depth having the least encoding error by comparing encoding errors according to depths of the coding unit **900** to determine a coded depth, and set a corresponding partition type and a prediction mode as an encoding mode of the coded depth.

[0306] As such, the minimum encoding errors according to depths are compared in all of the depths of 1 through d, and a depth having the least encoding error may be determined as a coded depth. The coded depth, the partition type of the prediction unit, and the prediction mode may be encoded and transmitted as information about an encoding mode. Also, since a coding unit is split from a depth of 0 to a coded depth, only split information of the coded depth is set to 0, and split information of depths excluding the coded depth is set to 1.

[0307] The receiving unit **21** of the video decoding apparatus **20** may extract and use the information about the coded depth and the prediction unit of the coding unit **900** to decode the partition type **912**. The video decoding apparatus **20** may determine a depth, in which split information is 0, as a coded depth by using split information according to depths, and use information about an encoding mode of the corresponding depth for decoding.

[0308] FIGS. **20** through **22** are diagrams for describing a relationship between coding units **1010**, prediction units **1060**, and transformation units **1070**, according to an exemplary embodiment.

[0309] The coding units **1010** are coding units corresponding to coded depths determined by the video encoding apparatus **10**, in a maximum coding unit. The prediction units **1060** are partitions of prediction units of each of the coding units **1010**, and the transformation units **1070** are transformation units of each of the coding units **1010**.

[0310] When a depth of a maximum coding unit is 0 in the coding units **1010**, depths of coding units **1012** and **1054** are 1, depths of coding units **1014**, **1016**, **1018**, **1028**, **1050**, and **1052** are 2, depths of coding units **1020**, **1022**, **1024**, **1026**, **1030**, **1032**, and **1048** are 3, and depths of coding units **1040**, **1042**, **1044**, and **1046** are 4.

[0311] In the prediction units **1060**, some coding units **1014**, **1016**, **1022**, **1032**, **1048**, **1050**, **1052**, and **1054** are split into partitions for prediction encoding. In other words, partition types in the coding units **1014**, **1022**, **1050**, and **1054** have a size of 2N×N, partition types in the coding units **1016**, **1048**, and **1052** have a size of N×2N, and a partition type of the coding unit **1032** has a size of N×N. Prediction units and partitions of the coding units **1010** are smaller than or equal to each coding unit.

[0312] Transformation or inverse transformation is performed on image data of the coding unit **1052** in the transformation units **1070** in a data unit that is smaller than the coding unit **1052**. Also, the coding units **1014**, **1016**, **1022**, **1032**, **1048**, **1050**, and **1052** in the transformation units **1070** are different from those in the prediction units **1060** in terms of sizes and shapes. In other words, the video encoding apparatus **10** and the video decoding apparatus **20** may perform intra prediction, motion estimation, motion compensation, transformation, and inverse transformation individually on a data unit in the same coding unit.

[0313] Accordingly, encoding is recursively performed on each of coding units having a hierarchical structure in each region of a maximum coding unit to determine an optimum coding unit, and thus coding units having a recursive tree structure may be obtained. Encoding information may include split information about a coding unit, information about a partition type, information about a prediction mode, and information about a size of a transformation unit. Table 1 shows the encoding information that may be set by the video encoding apparatus **10** and the video decoding apparatus **20**.

TABLE 1

Split Information 0 (Encoding on Coding unit having Size of 2N × 2N and Current Depth of d)					
			Size of Transformation Unit		
	Partition Type		Split Information 0 of Transformation Unit	Split Information 1 of Transformation Unit	
Prediction Mode	Symmetrical Partition Type	Asymmetrical Partition Type			Split Information 1
Intra Inter Skip (Only 2N × 2N)	2N × 2N 2N × N N × 2N N × N	2N × nU 2N × nD nL × 2N nR × 2N	2N × 2N	N × N (Symmetrical Type) N/2 × N/2 (Asymmetrical	Repeatedly Encode Coding Units having Lower Depth

TABLE 1-continued

Split Information 0 (Encoding on Coding unit having Size of 2N × 2N and Current Depth of d)					
	Partition Type		Size of Transformation Unit		
Prediction Mode	Symmetrical Partition Type	Asymmetrical Partition Type	Split Information 0 of Transformation Unit	Split Information 1 of Transformation Unit	Split Information 1
				Type)	of d + 1

[0314] The output unit **12** of the video encoding apparatus **10** may output the encoding information about the coding units having a tree structure, and the receiving unit **21** of the video decoding apparatus **20** may extract the encoding information about the coding units having a tree structure from a received bit stream.

[0315] Split information indicates whether a current coding unit is split into coding units of a lower depth. If split information of a current depth d is 0, a depth, in which a current coding unit is no longer split into a lower depth, is a coded depth, and thus information about a partition type, prediction mode, and a size of a transformation unit may be defined for the coded depth. If the current coding unit is further split according to the split information, encoding is independently performed on four split coding units of a lower depth.

[0316] A prediction mode may be one of an intra mode, an inter mode, and a skip mode. The intra mode and the inter mode may be defined in all partition types, and the skip mode is defined only in a partition type having a size of 2N×2N.

[0317] The information about the partition type may indicate symmetrical partition types having sizes of 2N×2N, 2N×N, N×2N, and N×N, which are obtained by symmetrically splitting a height or a width of a prediction unit, and asymmetrical partition types having sizes of 2N×nU, 2N×nD, nL×2N, and nR×2N, which are obtained by asymmetrically splitting the height or width of the prediction unit. The asymmetrical partition types having the sizes of 2N×nU and 2N×nD may be respectively obtained by splitting the height of the prediction unit in 1:3 and 3:1, and the asymmetrical partition types having the sizes of nL×2N and nR×2N may be respectively obtained by splitting the width of the prediction unit in 1:3 and 3:1

[0318] The size of the transformation unit may be set to be two types in the intra mode and two types in the inter mode. In other words, if split information of the transformation unit is 0, the size of the transformation unit may be 2N×2N, which is the size of the current coding unit. If split information of the transformation unit is 1, the transformation units may be obtained by splitting the current coding unit. Also, if a partition type of the current coding unit having the size of 2N×2N is a symmetrical partition type, a size of a transformation unit may be N×N, and if the partition type of the current coding unit is an asymmetrical partition type, the size of the transformation unit may be N/2×N/2.

[0319] The encoding information about coding units having a tree structure may include at least one of a coding unit corresponding to a coded depth, a prediction unit, and a minimum unit. The coding unit corresponding to the coded depth may include at least one of a prediction unit and a minimum unit containing the same encoding information.

[0320] Accordingly, it is determined whether adjacent data units are included in the same coding unit corresponding to the coded depth by comparing encoding information of the adjacent data units. Also, a corresponding coding unit corresponding to a coded depth is determined by using encoding information of a data unit, and thus a distribution of coded depths in a maximum coding unit may be determined.

[0321] Accordingly, if a current coding unit is predicted by referring to adjacent data units, encoding information of data units in deeper coding units adjacent to the current coding unit may be directly referred to and used.

[0322] Alternatively, if prediction encoding is performed on a current coding unit by referring to adjacent coding units, the data units adjacent to the current coding unit are searched using encoded information of the data units, and the searched adjacent coding units may be referred to for predicting the current coding unit.

[0323] FIG. **23** is a diagram for describing a relationship between a coding unit, a prediction unit, and a transformation unit, according to encoding mode information of Table 1.

[0324] A maximum coding unit **1300** includes coding units **1302**, **1304**, **1306**, **1312**, **1314**, **1316**, and **1318** of coded depths. Here, since the coding unit **1318** is a coding unit of a coded depth, split information may be set to 0. Information about a partition type of the coding unit **1318** having a size of 2N×2N may be set to be one of a partition type **1322** having a size of 2N×2N, a partition type **1324** having a size of 2N×N, a partition type **1326** having a size of N×2N, a partition type **1328** having a size of N×N, a partition type **1332** having a size of 2N×nU, a partition type **1334** having a size of 2N×nD, a partition type **1336** having a size of nL×2N, and a partition type **1338** having a size of nR×2N.

[0325] A transformation unit split information (TU size flag) is a type of transformation index; a size of a transformation unit corresponding to a transformation index may be modified according to a prediction unit type or a partition type of a coding unit.

[0326] When the partition type is set to be symmetrical, i.e. the partition type **1322** (2N×2N), **1324** (2N×N), **1326** (N×2N), or **1328** (N×N), a transformation unit **1342** having a size of 2N×2N is set if split information (TU size flag) of a transformation unit is 0, and a transformation unit **1344** having a size of N×N is set if split information (TU size flag) of a transformation unit is 1.

[0327] When the partition type is set to be asymmetrical, i.e., the partition type **1332** (2N×nU), **1334** (2N×nD), **1336** (nL×2N), or **1338** (nR×2N), a transformation unit **1352** having a size of 2N×2N is set if a TU size flag is 0, and a transformation unit **1354** having a size of N/2×N/2 is set if a TU size flag is 1.

[0328] Referring to FIG. 23, the TU size flag is a flag having a value or 0 or 1, but the TU size flag is not limited to 1 bit, and a transformation unit may be hierarchically split having a tree structure while the TU size flag increases from 0. The transformation unit split information (TU size flag) may be used as an example of a transformation index.

[0329] In this case, when a maximum size of a transformation unit for transformation unit split information is used with a minimum size of the transformation unit, the size of the actually used transformation unit may be represented. The video encoding apparatus **10** may encode maximum transformation unit size information, minimum transformation unit size information, and maximum transformation unit split information. The encoded, maximum transformation unit size information, the minimum transformation unit size information, and the maximum transformation unit split information may be inserted into a SPS. The video decoding apparatus **20** may use the maximum transformation unit size information, the minimum transformation unit size information, and the maximum transformation unit split information for video decoding.

[0330] For example, (a) if a size of a current encoding unit is 64×64, and a maximum transformation unit is 32×32, (a-1) a size of a transformation unit is 32×32 when transformation unit split information is 0; (a-2) a size of a transformation unit is 16×16 when transformation unit split information is 1; and (a-3) a size of a transformation unit is 8×8 when transformation unit split information is 2.

[0331] Alternatively, (b) if a size of a current encoding unit is 32×32, and a minimum transformation unit is 32×32, (b-1) a size of a transformation unit is 32×32 when transformation unit split information is 0, and since the size of a transformation unit cannot be smaller than 32×32, no more transformation unit split information may be set.

[0332] Alternatively, (c) if a size of a current encoding unit is 64×64, and maximum transformation unit split information is 1, transformation unit split information may be 0 or 1, and no other transformation split information may be set.

[0333] Accordingly, when defining a transformation unit as 'RootTuSize' when the maximum transformation unit split information is 'MaxTransformSizeIndex', a size of the minimum transformation unit is 'MinTransformSize', and transformation unit split information is 0, a size of a minimum transformation unit 'CurrMinTuSize' which is available in a current coding unit may be defined by Equation (1) below.

$$\text{CurrMinTuSize}=\max(\text{MinTransformSize},\text{RootTuSize}/(2^\wedge\text{MaxTransformSizeIndex})) \quad (1)$$

[0334] In comparison with the size of the minimum transformation unit 'CurrMinTuSize' that is available in the current coding unit, the transformation unit size 'RootTuSize' which is a size of a transformation unit when transformation unit split information is 0 may indicate a maximum transformation unit which may be selected in regard to a system. That is, according to Equation (1), 'RootTuSize/(2^MaxTransformSizeIndex)' corresponds to a size of a transformation unit that is obtained by splitting 'RootTuSize,' which is a size of a transformation unit when transformation unit split information is 0, by the number of splitting times corresponding to the maximum transformation unit split information, and 'MinTransformSize' is a size of a minimum transformation unit, and thus a smaller value of these may be 'CurrMinTuSize' which is the size of the minimum transformation unit that is available in the current coding unit.

[0335] The size of the maximum transformation unit 'RootTuSize' may be varied according to a prediction mode.

[0336] For example, if a current prediction mode is an inter mode, RootTuSize may be determined according to Equation (2) below. In Equation (2), 'MaxTransformSize' refers to a size of a maximum transformation unit, and 'PUSize' refers to a size of a current prediction unit.

$$\text{RootTuSize}=\min(\text{MaxTransformSize},\text{PUSize}) \quad (2)$$

[0337] In other words, if a current prediction mode is an inter mode, the size of the transformation unit size 'RootTuSize' when transformation unit split information 0 may be set to a smaller value from among the size of the maximum transformation unit and the size of the current prediction unit.

[0338] If a prediction mode of a current partition unit is an intra mode, 'RootTuSize' may be determined according to Equation (3) below. 'PartitionSize' refers to a size of a current partition unit.

$$\text{RootTuSize}=\min(\text{MaxTransformSize},\text{PartitionSize}) \quad (3)$$

[0339] In other words, if a current prediction mode is an intra mode, the size of the transformation unit 'RootTuSize' when transformation unit split information is 0 may be set by a smaller value from among the size of the maximum transformation unit and the size of the current partition unit.

[0340] However, it should be noted that 'RootTuSize' which is the current maximum transformation unit size and is varied according to a prediction mode of a partition unit is an example, and that factors for determining the size of the current maximum transformation unit size are not limited thereto.

[0341] Accordingly, as a loop filtering area or a loop filter is determined in consideration of a minimum distance between a pixel in a coding unit and a border of the pixel, and a filter length of a loop filter for loop filtering performed based on coding units, an operation delay or an operation load for importing data necessary for loop filtering may be minimized.

[0342] Moreover, loop filtering may be set such that deblocking filtering and loop filtering are not repeatedly performed for a current coding unit so that repeated operation may be minimized. In addition, even for an external pixel of a current coding unit, in order that loop filtering may be performed using pixels that are already imported and easily accessible, a loop filtering area or a filter vertical length of a loop filter may be extended to thereby expand pixels to be used for loop filtering. If pixels used for loop filtering are increased, encoding error may be further reduced by the loop filtering.

[0343] Accordingly, an increase in an operation delay or an operation load caused by loop filtering based on a coding unit may be minimized, and loop filtering may be performed using as many pixels as possible, and thus loop filtering may be performed effectively.

[0344] The block diagrams illustrated in the drawings may be construed by a person of ordinary skill in the art that it is a form conceptually expressing circuits for implementing the principles described. Similarly, it is obvious to a person of ordinary skill in the art that a flowchart, a status transition view, a pseudo-code, or the like, may be substantially expressed in a computer-readable medium to denote various processes which can be executed by a computer or a processor whether or not the computer or the processor is clarified or not. Thus, the foregoing exemplary embodiments may be created as programs which can be executed by computers and may be implemented in a general digital computer operating the programs by using a computer-readable recording medium. The computer-readable medium may include storage mediums such as a magnetic storage medium (e.g., a ROM, a floppy disk, a hard disk, or the like), an optical reading medium (e.g., a CD-ROM, a DVD, or the like).

[0345] Functions of various elements illustrated in the drawings may be provided by the use of dedicated hardware as well as by hardware which is related to appropriate software and can execute the software. When provided by a processor, such functions may be provided by a single dedicated processor, a single shared processor, or a plurality of individual processors which can share some of the functions. Also, the stated use of terms "processor" or "controller" should not be construed to exclusively designate hardware which can execute software and may tacitly include digital signal processor (DSP) hardware, a ROM for storing software, a RAM, and a non-volatile storage device, without any limitation.

[0346] Elements expressed as units for performing particular functions may cover a certain method performing a particular function, and such elements may include a combination of circuit elements performing particular functions, or software in a certain form including firmware, microcodes, or the like, combined with appropriate circuits to perform software for performing particular functions.

[0347] Designation of 'an exemplary embodiment' of the principles described and various modifications of such an expression may mean that particular features, structures, characteristics, and the like, in relation to this exemplary embodiment are included in at least one exemplary embodiment of the principle. Thus, the expression 'an exemplary embodiment' and any other modifications disclosed throughout the entirety of the disclosure may not necessarily designate the same exemplary embodiment.

[0348] In the specification, in a case of 'at least one of A and B', the expression of 'at least one among~' is used to cover only a selection of a first option (A), only a selection of a second option (B), or a selection of both options (A and B). In another example, in a case of 'at least one of A, B, and C', the expression of 'at least one among~' is used to cover only a selection of a first option (A), only a selection of a second option (B), only a selection of a third option (C), only a selection of the first and second options (A and B), only a selection of the second and third options (B and C), or a selection of all of the three options (A, B, and C). Even when more items are enumerated, it will be obvious to a person of ordinary skill in the art that they can be definitely extendedly construed.

[0349] While the present disclosure has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by one of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the following claims. The exemplary embodiments should be considered in a descriptive sense only and not for purposes of limitation. Therefore, the scope of the invention is defined not by the detailed description of the invention but by the following claims, and all differences within the scope will be construed as being included in the present invention.

1. A method of decoding a video using a video decoding processor, the method comprising:

extracting encoding information and encoded video data from a received bit stream;

decoding the encoded video data for each coding unit of the video data using the encoding information;

performing loop filtering on the decoded video data of each coding unit using internal pixels of the coding unit, based on a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit; and

restoring the video by combining the decoded video data and the loop-filtered decoded video data on which the loop filtering is performed, for each coding unit.

2. The method of claim **1**, wherein the performing of the loop filtering comprises:

modifying a loop filtering method, based on (i) a minimum distance between the pixel and a border of the coding unit and (ii) a filter length of the loop filter; and

performing the loop filtering on the coding unit using the modified loop filtering method,

wherein the loop filtering method comprises at least one of a first method of determining a loop filtering area including central pixels of loop filtering within an internal area a predetermined distance away from at least one border of the coding unit and a second method of determining the loop filter such that a filter length of the loop filter is equal to or smaller than the minimum distance between the pixel and the border of the coding unit, and

wherein the predetermined distance between at least one border of the coding unit and the internal area is equal to or greater than the filter length.

3. The method of claim **2**, wherein the performing of the loop filtering comprises determining the loop filtering method based on a minimum vertical distance between upper and lower borders of the coding unit and a filter vertical length for vertical filtering of the loop filter,

wherein the filter vertical length is determined to be shorter than a filter horizontal length for horizontal filtering of the loop filtering.

4. The method of claim **2**, wherein the first method further comprises determining the loop filtering area in an area except an area of the coding unit whose data is modified by deblocking filtering.

5. The method of claim **2**, wherein the first method further comprises extending at least one of the determined loop filtering area and the filter vertical length of the loop filter based on a filter vertical length of the deblocking filter of the coding unit.

6. The method of claim **1**, wherein the coding unit is included in coding units having a tree structure included in a maximum coding unit, and

the coding units having a tree structure are coding units of a coded depth which are hierarchically determined according to depths in the same region of the maximum coding unit and independently determined in different regions, and

wherein the coding units of the coded depth are determined to independently output encoding results for each coding unit according to depths, from among coding units according to depths that are configured hierarchically according to depths indicating the number of splitting times of the maximum coding unit.

7. A method of encoding a video by using a video encoding processor, the method comprising:

encoding the video data based on a coding unit obtained by splitting a video data into spatial domains;

performing loop filtering on the coding unit by using internal pixels of the coding unit, based on a minimum distance between a pixel, on which loop filtering is to be performed, from among video data of the coding unit, and a border of the coding unit, and a filter length of the loop filter; and

outputting encoding information related to an encoding method and the encoded video data for each of the coding units.

8. The method of claim **7**, wherein the performing the loop filtering comprises:

modifying the loop filtering method, based on (i) a minimum distance between the pixel and a border of the coding unit and (ii) a filter length of the loop filter; and

performing the loop filtering on the coding unit using the modified loop filtering method,

wherein the loop filtering method comprises at least one of a first method of determining a loop filtering area including central pixels for loop filtering within an internal area that is a predetermined distance away from at least one border of the coding unit and a second method of determining the loop filter such that a filter length of the loop filter is equal to or smaller than the minimum distance between the pixel and the border of the coding unit, and

wherein the predetermined distance between the at least one border of the coding unit and the internal area is equal to or greater than the filter vertical length.

9. The method of claim **8**, wherein the performing the loop filtering comprises determining the loop filtering method based on a minimum vertical distance between upper and lower borders of the coding unit and a filter vertical length for vertical filtering of the loop filter,

wherein the filter vertical length is determined to be shorter than a filter horizontal length for horizontal filtering of the loop filtering.

10. The method of claim **8**, wherein the first method further comprises determining the loop filtering area in an area of the coding unit except an area whose data is modified by deblocking filtering; and

extending at least one of the determined loop filtering area and the filter vertical length of the determined loop filter based on a filter vertical length of the deblocking filter of the coding unit.

11. The method of claim **7**, wherein the encoding comprises:

splitting a picture into a maximum coding unit a data unit of the largest size for encoding the picture; and

determining coding units having a tree structure which are hierarchically determined according to depths in the same region of the maximum coding unit and independently in different regions, from among coding units according to depths that are configured hierarchically according to depths indicating the number of spatial splitting times of the maximum coding unit by independently determining a coding unit of a coded depth at which an encoding result is to be output for each coding unit according to depths,

wherein in the performing of loop filtering, loop filtering is performed on a coding unit included in each of the encoding units having a tree structure.

12. A video decoding apparatus, comprising:

a receiving unit to that extracts encoding information and encoded video data from a received bit stream;

an adaptive loop filter (ALF) coding unit that decodes the encoded video data for each coding unit of the video data using the encoding information, and performs loop filtering on the decoded video data of each coding unit using internal pixel values of the coding unit, based on (i) a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit, and (ii) a filter length of the loop filter; and

a restoring unit that restores the video by combining the decoded video data and the loop-filtered decoded video data on which loop filtering is performed, for each of the coding units.

13. A video encoding apparatus, comprising:

an ALF coding unit that performs loop filtering on a coding unit using internal pixel values of the coding unit, based on (i) a minimum distance between a pixel on which loop filtering is to be performed and a border of the coding unit, and (2) a filter length of the loop filter, the coding unit obtained by splitting video data into spatial domains, and encodes video data for each of the coding units; and

an output unit that outputs encoding information related to an encoding method and the encoded video data for each of the coding units.

14. A computer readable recording medium having recorded thereon a program for executing the method of claim **1**.

15. A computer readable recording medium having recorded thereon a program for executing the method of claim **7**.

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